

Electrochemical and Metallurgical Industry

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Electrochemical and Metallurgical Industry

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ADVERTISING RATES GIVEN ON APPLICATION.

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Zinc in the Electric Furnace.

It is with peculiar pleasure that we approach this subject, for zinc is "par excellence" the electrical metal. In the first half of the nineteenth century, zinc as the negative of the primary cell was the only source of electrical energy available to the experimenter. Without it the researches of Faraday, which are the foundations of the electric dynamo, would never have been possible. Up to the present day it has a wide use in practical electrical engineering, though to-day secondary cells are rapidly displacing the primary battery. Electricity thus owes a debt to zinc. Electrolytic copper-refining has, by its cheap separation of the precious metals and attendant production of a pure high-conductivity copper, been helpful to electrical engineering. The great basic future use for aluminum—a metal commercially possible only by electrical aid—will be for electrical conductors. In both these instances electrometallurgy reacts broadly on electrical engineering, and there is a "community-of-interest" idea in their relations.

Dr. F. Meyer gave, in our January issue, a review which showed that there has been real progress made in the electrostatic separation of low-grade zinc-lead-silver ores. This is a courteous and gentlemanly coming of aid on the part of the metal's old rival—the electrostatic generator—to the metal. Electromagnetic separation of zinc-iron and zinc-iron-manganese ores is further evidence of the curious interdependence of metallurgy and electricity. Many attempts have been made to treat these low-grade ores by leaching and subsequent electrolytic reduction to metal, but either with this or with the Swinburne-Ashcroft process, there has been but small commercial success attained. Work has also been done since the days of the Cowles Brothers, in 1884, in the domain of reduction in the electric furnace. This had but little success up to the present day. However, Mr. G. De Laval, a versatile inventor, as is seen by his cream separator and his steam turbine, has developed a commercial electric zinc furnace, as we noted several months ago. His plant has been producing for some time electric spelter of extreme purity. This metal is pure enough to be used for the manufacture of the brass which is turned into cartridges at several governmental factories in Europe. It evidently has the requisite "physical properties" to stand the most rigid test, and is sold at a profit, because its high quality commands a high price. De Laval has used his commercial furnace almost exclusively on redistilling impure spelter or spelter products. He has, however, made some trials on the lower grade zinc ores found in abundance in the Scandinavian Peninsula. Whether he has preferred to keep tonnage of plant at maximum by working metal, and so does not care to use ore, or whether he is not now able to treat ore at a profit, is at this date unknown to us. The production of high-grade spelter in this country is limited to the New Jersey Zinc Co., an old, well-established, strong,

conservative concern, and the Edgar Zinc Co., controlled by the American Steel & Wire Co., a subsidiary company of the United States Steel Corporation. The brands, "Horse Head," "Bertha" and "Glendale," sell for from 2 to 4 cents above the market for "Prime Western." Here it is to be noticed that electrometallurgy has won its first victory in refining metal, just as it has done in the case of crucible steel or electrolytic copper refining, and electrolytic nickel refining. In these days of small profits, \$40 or \$80 per ton looms up as a pretty large differential, and it is believed that negotiations for the exploitation in this country of the De Laval furnace are under way at this time. This achievement gives encouragement to the solution of the problem of treating ores in the electric furnace. Heretofore, electric furnaces working on zinc ores have resembled the horse of Haroun-al-Raschid. This horse, it will be remembered, possessed a most glossy coat, beautiful ears and head—in short, it was the perfection of equine beauty. It had, however, one great fault. It was quite dead.

These experimental zinc electric furnaces were also perfect in all save one respect—they did not make any metal. Imperfect condensation caused the formation of "blue-powder," or zinc dust. If De Laval has solved the problem of the condensation of zinc, other men can effect it, too. If a large scale zinc furnace could be produced it would have exactly the same advantages that we have on several occasions enumerated for electric crucible steel and electric brass furnaces: (1) Large units in place of small units, with consequent smaller labor charge; (2) putting heat inside of furnace instead of forcing it through fire-clay; (3) ease of control over heat and thus over smelting operation; (4) if the furnace was durable, lower cost for renewals. There is no reason why this cannot be effected on a large scale, or why the same change from an externally heated retort to an electric furnace cannot be made in distilling and condensing zinc, as has been made in case of phosphorus and carbon disulphide. Whether this can be successfully done commercially is less certain. It is to be noted zinc is a much more important article of commerce than either phosphorus or carbon disulphide, and so more work has been done on the old zinc process than was the case with them. Further improvement of the old process is possible with zinc. Its metallurgy, though apparently simple, is really extremely complex, and so perhaps the right conditions cannot be held on large-scale electric furnaces. We hope that some one will take up this problem and try it out to the uttermost—to a flat failure or a pronounced success. It would be a satisfactory triumph of electrometallurgy if zinc ore were concentrated electrostatically and electromagnetically, and the concentrate reduced and refined electrothermically. But as in all things we shall see what we shall see.

The Effect of Ferro-Alloys.

The ferro-alloy industry is dear to a great many of our readers. The introduction of alloy-steels for high-speed tools has brought about a revolution in machine-shop practice. True, the production of special alloy-steels, when measured by tons and compared with the production of pig-iron, is ridiculously small. But this is not the way to look at the matter. Mr. R. A. Hadfield, one of the foremost among those who did

recognize the importance of this subject at an early moment, was perfectly justified in saying in his recent presidential address to the Iron and Steel Institute that if alloy-steels were now taken away there would be an end of progress, so much does advancing civilization depend upon the work of the modern steel metallurgist. Many of our conveniences, our comforts and—in war material—many of our defenses, are directly due to metallurgical research and the practice that springs from it. While the use of alloy-steels has been so rapid as to assume a revolutionary character, the manufacturers of ferro-alloys have not been sleeping, and it is with particular pleasure that we emphasize the part which the electric furnace has played in this field. But all this matter has been so fully discussed in articles and serials in our columns that we may refrain from saying here anything more. What we wish to call attention to in these notes is the fact that in spite of all practical progress we are far from having the subject well in hand; we are still very far from an exact classification of the practical achievements so as to be able to say that we perfectly understand the effect of the introduction of certain elements into steel.

How complicated the problem of solid solutions really is may best be judged by comparison with dilute aqueous solutions. In the latter case, whether or not we pretend to know the exact molecular or ionic constitution of the solution, yet to a certain extent we are enabled to predict what change in the physical properties (electric conductivity, etc.) will be produced by the addition of a given quantity of a certain salt. Here we have to deal with additive properties. But as yet we can predict very little of the kind in the case of solid solutions. Above all, however, the physical properties of an aqueous solution are determined by its chemical composition. This is not the case with solid solutions, as may be quickly appreciated in the case of iron-carbon alloys from Roozeboom's diagram (for instance, our Vol. II, page 49). In this case we have to do with a variety of compounds and solid solutions, and the physical condition of a sample of carbon-steel depends on the way in which it was cooled from the state of fusion; it depends on its previous history. Thus chemical composition is not everything, and chemical analysis cannot reveal everything we want to know concerning the alloy. If we consider how extremely complicated the study of alloys of iron with carbon alone is in itself, the increased complication will be at once manifest, which results from the introduction of another element into steel, thus giving rise to the possibility of further phases. The difficulty of a systematic investigation of such steels containing various elements was forcibly brought out in the introduction of Dr. Goldschmidt's article published in our last issue. Since the previous history of an alloy determines its physical properties, apparent differences in the results obtained by different investigators with alloys of the same chemical composition may be explained. There has already been done an enormous amount of research work in this field, but yet not too much. We are only in the beginning.

The limitation of chemical analysis as indicated above is well emphasized by some of the results recorded in this issue by Dr. Hans Goldschmidt, with respect to the effect of titanium

on the strength of steel. In spite of practically the same chemical composition there is a distinct difference in the physical properties of the two samples, when treated with titanium thermit or not. It is thus clear that to understand the subject, chemical analysis must be supplemented by microscopic investigation of the structure, and the results must be considered in the light of the theory of solid solutions, on the basis of Gibbs' and Roozeboom's views. However, the effect of the titanium-thermit treatment just noticed emphasizes another point. Here we have not simply the production of titanium-steel. (As a matter of fact, we have yet not found any exact and clear-cut statement of the effect of the introduction of titanium into steel.) Dr. Goldschmidt carefully emphasizes that at least part of the effect of the titanium-thermit treatment is due to the mechanical stirring of the bath, and the combination of nitrogen with titanium. For exactly the analogous reason, copper-silicon has long been used for copper castings, in order to combine with silicon the oxygen of the cuprous oxide dissolved in the copper. There is still another point. We know that the "occlusion" of gases may have an enormous effect on the physical properties of a metal; thus the extreme hardness of electrolytic iron was found by Prof. C. F. Burgess to be due to the occlusion of hydrogen in it. "Occluded" gases may play a similar important part in other metals. However, enough has already been said to indicate the great complication of the problem while the necessity of solving it is manifest.



Metallurgical Geography.

The question of where a metallurgical plant should be placed depends on conditions favorable to the cheap production and easy sale of the finished product. There are three main factors which enter into the determining of the best location. These three factors are essential to production, the mine, the market and the fuel supply. These are fixed while capital and labor are flexible. In general, the smelter or concentrating mill is placed near the mine, while the refinery is placed near the market—a perfectly natural and to-be-expected distribution of metallurgical work. This is always the case where the ore is susceptible of being concentrated into a crude product in the ratio of several tons of ore to one of matte or metal. The location of both smelter and refinery is further influenced by the adjacency of the fuel supply. As the attraction of the two forces on a particle results in a dynamic equilibrium, so also will the interaction of economic forces result in some sort of a stable equilibrium. Thus iron ore from Lake Superior meets coke from Connellsburg most favorably on the shores of Lake Erie. Silver-lead ores are either smelted at Leadville with coke brought from the Pueblo district, or are brought to Pueblo and smelted there. The base bullion from these Colorado plants, and also the Utah and Mexican plants, is brought to some center of consumption, Omaha, Denver, Chicago or New York, to be desilverized and refined. Within a trust, which is an industrial unit, there is free play of economic forces, and the result of these forces is advantageous to cheap production. Nearness to a financial center is another reason for placing the refinery near the market, for refined metal is first-class collateral for loans. Then there is a floating supply of labor in all large cities.

A case similar to that found with lead is found with copper and nickel. The largest nickel smelter is at Sudbury, while the refinery is at New York Harbor. Copper is usually brought into a crude product, either "converter bars" or "anodes," at the mines or at some railroad center near the mines, while the refining is effected to a large extent in five large plants on New York Harbor. Zinc is usually concentrated mechanically or electromagnetically near the mine, but is usually brought to metal near a coal field or some other supply of potential energy, as natural gas. The larger proportion of coal, two to four tons needed to treat one ton of ore, makes the fuel supply the dominant factor in the metallurgical geography of the zinc plant. Aluminum, which resembles zinc somewhat chemically, and in a broad way metallurgically, is brought in form of concentrated pure alumina to Niagara Falls, Massena, or Shawinigan Falls, where it meets its source of potential energy—the electric current.

In the location of plants, many interesting phases of development will arise in the future. Of great bearing is the fact that many manufacturing centers are usually not remote from the coal fields, and often situated directly in the coal fields. Fortunately, for the wide industry of the country, in more than half of the States are found coal supplies. The vast sedimentary deposits of rock in North America are broken through only in spots by igneous intrusions. Coal measures are found associated with these other sedimentary deposits. In the past this wide distribution of potential energy has had a peculiar, fortunate influence on American industry. As a direct result of coal, Pittsburg, Birmingham, Chicago, Cleveland, Pueblo have arisen as great metallurgical centers. New York, though near the anthracite fields, with its great harbor and its connection with domestic and foreign commerce, is in a different class, almost by itself. In the future there will be a further concentration of metallurgical plants and the resulting associated manufacturing plants to these centers. Along with this there will be considerable development of electrochemical works near these centers. The water-power installations, as at Niagara, Shawinigan, the "Soo" and elsewhere, have two special advantages for electrochemical industries; first, the low cost of power and, second, the fact that no capital is tied up in power plants. This for a new enterprise allows all possible capital to be invested in the plant. For these reasons there is every likelihood that these centers will grow. On the other hand, with cheap coal or blast furnace gas, power is nearly as cheap as at the water falls. Coal is used for many other purposes, evaporating liquids, drying solids, roasting and calcinating materials, melting metals, etc., etc. This will strike a balance in some cases in favor of the manufacturing center near coal. Strong competition in the lines of prime-movers and electric generators, especially that competition due to the entrance into this double field of the largest engine building concern and the two large electrical companies, guarantees that the capital outlay will be kept low. Thus, the rapid and free growth of America will increase by the interdependence of metallurgy and electricity, during the twentieth century, the importance of these wonderful coal fields so extended and so rich. It will be to the lot of some future Mahan to sketch the influence of coal power on industrial history.

Buffalo Meeting of the American Chemical Society.

The following preliminary programme has been issued for the thirty-second general meeting of the American Chemical Society to be held in Buffalo, N. Y., from June 22 to 24. The sessions will be held in the rooms of the Buffalo Society of Natural Sciences.

Thursday, June 22, 10:00 a. m.—After a brief address of welcome by Herbert P. Bissell, on behalf of the Buffalo Society of Natural Sciences, and a response by President Francis P. Venable, for the society, the following addresses will be given:

"The Classification of Carbon Compounds," by Marston T. Bogart.

"Some Recent Advances in Physiological Chemistry," by John H. Long.

These addresses will be followed by selected papers of general interest.

2 p. m.—Meetings of the Section of Agriculture, Sanitary and Biological Chemistry, with John H. Long, as chairman; of Physical Chemistry, with W. R. Whitney, as chairman; and of Organic Chemistry, with Marston T. Bogart, as chairman.

4 p. m.—The members of the society will visit the Gratwick Laboratory.

8 p. m.—An address by Francis A. J. Fitzgerald, on "The Electrochemical Industries in Niagara Falls."

Friday, June 23, 9 a. m.—An address by Victor Lenher, on "Telleurium," to be followed by brief reports from colleges and universities of the researches carried on during the past year. The Section of Inorganic Chemistry, with Victor Lenher, as chairman, will then meet, and the Section of Industrial Chemistry, with F. A. J. Fitzgerald, as chairman.

2 p. m.—Excursions to visit industrial establishments in Buffalo.

8 p. m.—A subscription dinner at Hotel Iroquois.

Saturday, June 24, 9 a. m.—Brief adjourned sessions of the sections of a general session, according to the exigencies of the programme, to be followed by an excursion to Niagara Falls.

Society of Chemical Industry.

The general meeting of the Society of Chemical Industry, which will be held in London, beginning July 10, promises to become a most splendid and enjoyable affair. From reports received from England it is evident that the enthusiasm is running high on the other side of the Atlantic in respect of the welcome and reception of the Americans, and that no efforts are spared to make the coming meeting as memorable as that of last year in this country.

The Hotel Russell will be the headquarters of the American visitors during the week to be spent in London. The provisional programme for this week is as follows:

Monday, July 10.—The annual meeting, at which Dr. Wm. H. Nichols will deliver the presidential address, will be held at 12.00 or 12.30 p. m., and will, as usual, be preceded by the Council meeting. It will be held at the University College, London, by permission of the Council, and a light lunch will be provided by the University authorities. At 3.30 p. m. conveyances will be provided to drive members through Hyde Park and Richmond Park to Richmond, where Sir Max Waechter (of Baesler, Waechter & Co.) and Lady Waechter will give a garden party. The picture galleries of Sir Frederick Cook will be open for inspection. Drive back to hotel. At 9.00 or 9.30 p. m. there will be a reception with music, supper, etc., at the Botanical Gardens, Regent's Park, which will be illuminated for the occasion.

Tuesday, July 11.—Excursion down the river on one of the London County Council's new steamers, to the Royal Arsenal,

admission to which has been obtained by Dr. Hodgkinson. (This is the first time that the Government authorities permit a party of foreigners to visit the Arsenal.) The party will be conducted around the works by the director of artillery. Thence by steamer to the Ship Hotel, Greenwich, where a fish lunch will be provided, after which Greenwich Hospital, including the Museum and Nelson relics, will be visited, and the party will be shown over the Royal Observatory by the astronomer royal. In the evening there will be a special reception by the Right Honorable the Lord Mayor of London at the Mansion House.

Wednesday, July 12.—Windsor and the neighborhood will be visited, with special permits to view the Castle. The party will afterwards drive to Virginia Water and the Mausoleum at Frogmore, and after lunch Eton School and the playing fields will be visited. At 7.00 p. m. the annual banquet will be held in the Goldsmith's Hall by permission of the chief warden and the Council of the Goldsmiths' Co. There will be dining accommodation for 170 only. Places will, of course, be found for the visitors, and if the English members swell the total beyond that number, they (the English members) will ballot for places. For those who do not obtain admission there will be an overflow dinner at the historic hall of the Merchant Tailors' Co., together with the ladies of the party. All will subsequently unite in a conversazione and musical evening in the reception rooms of the Goldsmiths' Hall, where all the historic and almost sacred plate will be on view.

Thursday, July 13.—Train to Bisley to see the National Shooting Competition. The party will then proceed to Haslemere, and a garden party will be given by Mr. and Mrs. Garton at Lythe Hill. The home of Tennyson, which adjoins the estate of Mr. and Mrs. Garton, will be visited, as well as the Punch Bowl and Hindhead, thus comprising some of the most beautiful of Surrey scenery.

Friday, July 14.—Parties to be arranged under suitable leaders to places of archaeological and historic interest, such as Westminster Abbey, St. Paul's Cathedral, the Tower of London, the Royal Mint, etc., also Whitbread's Brewery, Price's Patent Candle Co., Clarke, Nickols & Coombs' confectionery works, City of London Electric Lighting Co.'s power station, and in the evening, opera or theater, as the case may be.

Saturday, July 15.—Messrs. Burroughs, Wellcome & Co.'s works at Dartford will be visited, after which a garden party will be given by the Wellcome Club. In the evening there will be a special dinner and reception at Earls Court Exhibition.

Sunday, July 16.—Train to Canterbury, service in the Cathedral; then train to Dover to visit the Castle, and lunch, and return to London.

Washington Meeting of the American Institute of Mining Engineers.

The thirty-fifth annual meeting of the American Institute of Mining Engineers was held in Washington, D. C., from May 2 to 4, under the presidency of Mr. James Gayley. Both with respect to the social functions and to the professional proceedings the meeting was a decided success. While the evening session of May 2 was attended by some seventy-five members and guests, the number of those participating on Thursday afternoon in the excursion to the Indian Head proving grounds was at least twice as large.

Following the usual custom of the Institute, only a small number of the papers on the programme (some seven out of more than forty) were read at the meeting. Compared with the custom, for instance, of the American Electrochemical Society, the policy of the Institute has one distinct advantage in that ample time is left for thorough discussion. As a matter of fact, the professional proceedings of the Washington meeting turned out particularly successful, by the lively discussions elicited by some of the papers.

TUESDAY SESSION.

At the evening meeting on May 2, after the speeches of welcome and the reply by President Gayley, Dr. Chas. Kirchoff reported on the progress of the United Engineering Building, while the secretary, Dr. R. W. Raymond, spoke of the incorporation of the Society, which became necessary on account of its property rights in the Engineering Building.

Dr. Raymond then read biographical sketches of two highly distinguished members of the Institute, Sir Lowthian Bell and Dr. Thomas M. Drown, the biography of Sir Lowthian being written by Prof. H. M. Howe, that of Dr. Drown by Dr. Raymond.

WEDNESDAY SESSION.

The features of the Wednesday session were two animated discussions; one on the subject of Mr. Gayley's famous dry-blast experiment, the other on wrought iron versus steel. Mr. Gayley gave some additional data on his dry-blast process, and replied to some of his critics. A large number of members participated in the discussion, among them Mr. J. E. Johnson, Jr., with quite an elaborate paper. (An abstract of a very interesting analysis of the dry-blast process by Dr. J. W. Richards may be found under Synopsis of Current Literature on another page of this issue.)

The discussion on wrought iron versus steel was started by a paper by Mr. Jas. P. Roe, on the production and characteristics of wrought iron. Mr. Roe, well known by his mechanical puddling process, discussed the reactions of the puddling process, the structure of puddled iron and its relation to the physical properties, the resistance to oxidation, and finally summed up the conditions essential to successful puddling as follows: Large scale manufacture, adequate mechanical means, cinder of proper composition, a flame of the right composition and temperature, a relatively permanent furnace lining, a relatively small loss of iron, and simplicity of means and method.

Mr. C. E. Stafford, Dr. C. B. Dudley, Dr. Cushman, Mr. J. Hartshorne and Mr. N. B. Wittman participated in the discussion. It was emphasized that while the advent of mild steel caused a considerable reduction in the number of puddling furnaces, now the opposite tendency is observed. Wrought iron is now preferred for many uses, especially when the resistance to fiber stress is of greater importance than high tensile strength. Wrought iron has now a better chance with large unit manufacture. Mr. Stafford spoke very favorably of the Roe puddling process, which, in his opinion, constitutes a great advance in economic metallurgy.

THURSDAY SESSION.

In the first paper of the Thursday session, Mr. Geo. T. Wickes described a machine for drawing coke from beehive ovens.

The other papers of this session were devoted to geological subjects. Mr. M. R. Campbell presented a paper on "A Classification of Coals and Lignites," based upon ultimate analysis. Prof. James F. Kemp discussed "The Copper Deposits of San Jose, Tamanlipas, Mexico," and Mr. A. C. Spencer the "Origin of the Magmatic Vein Waters in Alaska."

A good deal of the success of the meeting was due to the excellent preparations made by the local committee, with Mr. S. F. Emmons, of the United States Geological Survey, as chairman, and Mr. John M. Boutwell, also of the Geological Survey, as secretary.

Notes.

AMERICAN ELECTROCHEMICAL SOCIETY.—At the May meeting of the board of directors the following gentlemen were elected members of the Society: W. H. Kimball, Portland, Me.; A. S. Ramage, Detroit, Mich.; J. M. Woodward, Washington,

D. C.; C. A. Hansen, Madison, Wis.; J. W. Beckman, Tarentum, Pa. At the next meeting of the board of directors the names of the following gentlemen will come up for election: Henry F. Lewis, Boston, Mass.; Edgar F. Smith, University of Pennsylvania; Theodore W. Richards, Harvard University; Hubert Buckley, Niagara Falls, N. Y.

NEW YORK SECTION AMERICAN ELECTROCHEMICAL SOCIETY.—The last meeting of the session was held on the evening of May 23 in the hall of the Chemists' Club. There were three papers, all of which were listened to with great interest. Prof. Turner, of Columbia University, described the equipment of the electrochemical engineering laboratory of Columbia University, and gave a review of some of the work done there during the last year. Some of the specially interesting lines of work were the production of boron carbide and the manufacture of ferro-alloys. With respect to the latter Messrs. G. W. Maynard and J. T. Morehead made some remarks in the discussion. Among other things Mr. Morehead stated that the monthly output of ferro-chromium by the Wilson Aluminium Co. is now 200 tons. The second paper dealt with the method of manufacturing alundum (artificial emery) in the electric furnace, the author being Mr. C. B. Jacobs, the inventor of the process which is in use at the Niagara works of the Norton Emery Wheel Co. (our Vol. I, page 15). Replying to some questions by Mr. H. N. Potter in the discussion, Mr. Jacobs gave a comparison of the uses of alundum and of carborundum, respectively. The third paper was presented by Mr. Maximilian Toch, on insulating paints and varnishes. He explained the problem and related very interesting observations he had made on the iron structure of the Sixth Avenue Elevated Railway in New York.

LEHIGH UNIVERSITY.—Among the subjects of theses to be presented by candidates for degrees at Lehigh University in June, are the following: C. H. Young on history, methods of manufacture and trade conditions of acetic acid (bachelor of arts); R. G. Kirk and F. C. Ryan on the briquetting of iron ores with cement (metallurgical engineer); L. F. Blume and S. H. Fleming on the polarization factor of electrolytic cells, and E. L. Rich and R. H. Smith on over-voltages in electrolysis (electrical engineer). The number of candidates for the degree of master of science is 1; bachelor of arts, 7; civil engineer, 31; mechanical engineer, 31; metallurgical engineer, 2; engineer of mines, 6; electrical engineer, 16; analytical chemist, 3; total, 97.

ELECTROPLATED LACES.—According to a recent consular report, the production of electroplated laces is another new industry in Continental Europe. Experiments were tried long ago to make non-conductive articles susceptible to the plating process, either dry or wet, by sprinkling them with a very fine powder of metal or graphite, or by immersing them in a solution of metallic salts. In this manner many articles, such as flowers, leaves, fruits and branches, and even delicate articles, received a metallic coating. An Italian engineer used the process to metallize parts of corpses to serve for medical demonstration, while a New York firm makes a specialty of electroplating first-baby shoes. A Brussels chemist devoted his attention especially to metallizing embroideries, and created wonderful effects. Until quite recently, however, they could not be made of practical value, and "only now a beginning has been made by an invention, the details of which are kept a secret. A stock company has been formed for its exploitation. According to the Paris *Cosmos* the company has created a sensation with their product." Laces are mainly treated. The colors of the metal coating and other properties can be regulated ad libitum. These metallic goods are used for table ornaments, decorating furniture coverings, wainscoting in parlors, and for incrustation of fine woods, and the metallized laces may be polished. Fashion will try what effect such gold or silver laces will have when used as trimmings for dresses or shawls or in the hair. Two processes of this kind were de-

scribed from United States patent specifications on page 67 of our Vol. I, and on page 34 of our Vol. II.

PROGRESS IN IRON AND STEEL METALLURGY.—The recent presidential address to the Iron and Steel Institute by the famous British steel expert, Mr. R. A. HADFIELD, was devoted to a review of the progress in iron and steel metallurgy. In this address Mr. Hadfield made some remarks on the use of electric furnace, but it seems that, unfortunately, he discussed only one—and the least promising—problem, i. e., the reduction of pig-iron from ores. He concludes that "blast furnace owners can breathe freely" until the day comes when electrical energy can be produced more cheaply. Mr. Hadfield paid a special tribute to "the early workers in this important branch of scientific manufacture, the Brothers Cowles, Waldo and Hunt, who fought their way to success through difficulties innumerable." Mr. Hadfield also discussed advances made in the manufacture of ordinary steel; the increasing uses of alloy-steels; the enormous importance of employing just exactly the right temperature in the heat treatment of steel; progress in metallography and low-temperature experiments; the industry of steel castings, and the manufacture of armor plates and projectiles.

CORRESPONDENCE.

Detinning.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—Permit me to call your attention to an error in "Analysis of Current Electrochemical Patents" in your May number. In the notice of "Process of Detinning," patented by F. von Kuegelen and G. O. Seward, Dr. Scholl states that this patent was assigned to the Union Carbide Co. The patent was, in fact, assigned to the Willson Aluminium Co.

Yours very truly,

WILLSON ALUMINUM CO.,

Holcomb Rock, Va.

By George O. Seward

Refractory Materials for Metallurgical Furnaces.

To the Editor of Electrochemical and Metallurgical Industry:

SIR:—In the design of any furnace, the character of the lining and of the bricks that back the lining and form the arch and walls is of paramount importance. Materials that withstand the corrosive action of the molten slag or metal, and at the same time are not affected by high heat, usually have small tensile strengths. It is therefore always necessary to make use of their compressive strength, and let the proper iron work outside carry the tensile strains of the structure.

This chain of facts permits of the use of large furnaces for cold iron is exceedingly strong. Where reliance is put on the tensile strength of fire-clay we have the small "graphite" or fire-clay crucible retort, or muffle used in the crucible furnace, the zinc furnace and annealing furnace respectively. Cast iron can only be used where the temperature does not much exceed 700° C.

Unfortunately, the knowledge of this important subject of refractories is scattered, illusive and indefinite. The makers of fire-brick have some valuable practical data due to this contact of the whole field, and the metallurgists in the special fields also know much that is useful and applicable. This, of course, must be true, for furnaces do make metal, and last for long periods, sometimes for years.

But this data which is placed before the metallurgist is unsatisfactory and unreliable. How unreliable and unsatisfactory is shown by the fact that the best blast furnace engineers,—men who, for mental ability, stand second to no other class in this country,—cannot accurately say, when blowing in

a new iron blast furnace, whether it will operate without relining for three months or twice that many years. Indeed, we were talking with two metallurgical engineers, when A said to B, "What do you know about the heat conductivity of fire-brick?" B replied, "I know this much, that it is a very important subject, and I would like to know a good deal about it." This is a lamented state of affairs for a profession that should base its knowledge on scientific facts. In the future it will not be enough to say put "two courses there" and "three here." We must know how many calories of heat for a given brick will pass through a cubic inch at definite temperature difference.

In electric furnaces, especially those which are permanent, refractories are an essential. It is obvious that an electric furnace has an advantage in putting the heat right in or next the charge. That the efficiency with which this heat is applied overbalances in some instances its cost as compared with heat derived from carbonaceous fuel. Consequently the materials which conceive this heat must be refractory, durable, and possess high heat insulating properties. In a copper matting furnace, the entire lower part is usually water jacketed and the lining is congealed slag. This allows of long campaigns. But an electric furnace, because of the high price of electric heat, cannot well be water-jacketed. Indeed, it is usually out of the question to water-jacket an electric furnace for electrical reasons alone. If water jackets are used in an electric furnace, they should only protect special points, as electrodes or tap holes.

Another most important branch is the class of refractories that transfer the heat from the fuel to the charge. In usual practice, strange as it seems, these are of fire-clay, the same that is used in keeping heat from going from the furnace to the outside. For two diametrically opposite purposes the same material is used. This is incredible, and a sufficient commentary on the backward state of our knowledge of refractories. In all crucible melting, in muffle roasting, in a by-product coke oven, in much chemical work, in many annealing furnaces, the heat must be forced through a poor conductor. Of course, chrome brick conduct heat much better than ordinary fire-clay brick, but their cost is \$170 or more per thousand. If a refractory brick would be made of magnetite or other conducting material and sold at a price equal to the best grades of fire-brick, or even as high as \$60 per thousand, it would find a warm welcome from the metallurgical profession. If such a brick "were true to size" and could be easily cut by the mason, it would be even more acceptable. But if such a brick could also be made in special shapes cheaply, if it could stand temperature changes without cracking, if it were non-porous, if it could stand high temperatures and fluing action of various materials, it would be the *ne plus ultra* for all purposes of indirect heating.

We have but touched on a few points in the résumé of this important subject. We hope that this will be investigated in the future most thoroughly, and that the subject will be attacked from the scientific and practical standpoint. Indeed, we confess ourselves optimists for the future of metallurgy and development in the line of refractories will give, let us hope, in the future, fair play for our optimism. For time always satisfies long-felt wants.

In conclusion, I might refer in this connection to the important serial on metallurgical calculations which Prof. Richards is now publishing in your journal—a series which will do much to simplify metallurgical knowledge of the country. If data for the conductivity of different makes of fire-clay brick, etc., were known, we could calculate loss by radiation, now called "unaccounted for," and thus check up the "heat balance sheet." This would make a surer and better method of determining the loss by radiation which should be known definitely.

WOOLSEY MCA. JOHNSON.

New York City.

The Borchers Furnace.

By F. A. J. FITZGERALD.

In the year 1849, Despretz presented to the Académie des Sciences, in Paris, certain papers that have considerable interest in connection with electric furnace work, and are by no means as well known as they ought to be. Despretz described how he had fused and volatilized various refractory substances, such as magnesia, silicon, boron, platinum, etc. Finally he read papers specially devoted to certain experiments, which, in his opinion, clearly demonstrated the fusion and volatilization of carbon. Moissan has since shown¹ that carbon is infusible at ordinary pressures, even when raised to the highest attainable temperature; but that does not lessen the interest in Despretz's paper, which contains much that is important.

The body of the furnace used by Despretz was made of cast iron, and had a movable cover. The latter carried a leather stuffing-box, through which a rod passed vertically, the rod being insulated by two glass plates and two small leather washers. At the end of the rod was a carbon terminal, the other carbon terminal being connected to another rod passing through a suitable tube in the side of the apparatus. The interior of the furnace body could be observed through two large tubes closed with thick plates of glass. A fifth tube could be connected either to a vacuum or compression pump, while another tube permitted connection with a manometer.

With this apparatus Despretz was able to make experiments, using either carbon resistors or arcs. When he wished to develop heat by means of a resistor he connected the carbon terminals carried by the vertical and horizontal rods with a small rod of carbon, through which the current was passed. When an arc was required the furnace was fitted with a different cover, so arranged that by means of a third rod the substance under examination could be introduced into the arc formed between two carbon rods.

The apparatus described above had a capacity of 10 litres, and was only used in experiments where it was desired to work under increased pressure. In experiments under atmospheric pressure the electric furnace was covered with a large bell-jar.

Despretz's source of current was 600 Bunsen cells, which could be connected in various ways, according to the nature of the experiment.

Several experiments were made with carbon rods through which the current was passed, and Despretz observed that when these rods became very hot they tended to bend, the carbon apparently becoming soft. Usually the experiments did not last long, for the carbon rods would presently break. Various kinds of carbon were used: retort carbon, sugar carbon, anthracite, etc. When the carbons broke, Despretz observed that the broken ends usually presented a fused appearance, and were converted into graphite. Although Despretz made analyses of the carbons, which seemed to show that they were very pure, it is probable that the impurities present formed carbides and gave the appearance of fusion.

Despretz notes an inconvenience in his experiments which has been experienced by many experimenters since his time. He says:

"Thus, if it is desired to demonstrate the volatilization of platinum in air or that of iron in a vacuum or in nitrogen, carbon is found mixed with the metal in the porcelain dish even when this is placed 1 decimeter above the carbon crucible in which is the substance submitted to the action of the electric arc."

He notes in various experiments the formation of graphite and a curious increase in the volume of the carbon under treatment.

"A rod of retort carbon 15 mm in diameter and 25 centi-

meters long, connected with the two terminals, closed the circuit of the battery of 600 cells connected in six parallel series.

"The pressure of nitrogen (used in the furnace) was two and a half atmospheres. The carbon was raised to a dazzling white heat, the substance seemed to collect at the lower part, and it broke at this point. The two separated parts had double their original diameter.

"This increase in volume by the action of heat alone could scarcely occur unless the substance had begun to fuse."

It is now known that certain forms of carbon increase greatly in apparent volume when converted into graphite.

An interesting experiment was made with a carbon rod which passed through a clay crucible filled with sand. The current was passed through the rod which "fused and volatilized. I obtained a sort of very hard fulgurite (lightning-tube) the interior of which was lined with smoky-quartz; the inner diameter of this tube was at least ten times that of the carbon."

Mr. Elihu Thomson has recently obtained a patent for making quartz tubes in this manner.²

Despretz also made several experiments on the effect of heat on diamond. For this purpose he used a tube furnace which he made by connecting the carbon terminals with a carbon tube in which the diamonds were placed. Despretz' paper may be found in *Comptes Rendus* No. 25, T XXIX, 1849.

This furnace, designed by Despretz, may be looked upon as the progenitor of the furnace known as the Borchers type. An

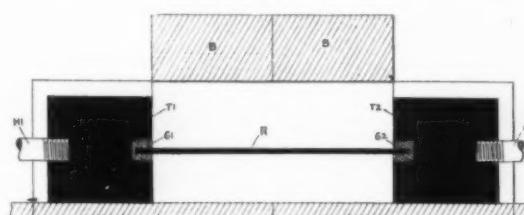


FIG. 1.—DIAGRAM OF BORCHERS FURNACE.

illustration of the Borchers furnace is given in Fig. 1. T₁ and T₂ are heavy carbon terminals which are connected electrically by the resistor R. The connections between the resistor and the terminals may be made by drilling holes in the terminals and packing with graphite, G₁ and G₂, as shown in the figure. The connections to the source of current are made at H₁ and H₂. The material to be heated surrounds the resistor R, and the furnace is covered by the bricks B. According to Borchers, all oxides may be reduced in this furnace.

The data given by Borchers for this furnace are as follows:

"An electromotive force of 0.3 to 0.4-volt is necessary to drive a current of 1 ampere through 1 mm. of a carbon pencil at the temperatures of these experiments, with a current density of 6 to 10 amperes per sq. mm. of sectional area."³

This would give a resistivity of 0.005 to 0.004 ohm, which is somewhat higher than required in the case of graphite rods, as will be shown later. It should also be observed that a current density of 6 to 10 amperes per square mm. of sectional area in carbons, having the resistivity of those mentioned, would give an enormously high temperature unless the diameter of the carbon was very small.

In designing a Borchers furnace the general principles that have been considered in dealing theoretically with the resistance furnace must be kept in mind. It is not necessary to

² U. S. patent 778,286, December 27, 1904. ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, vol. III., page 71.

³ "Electric Smelting and Refining," by W. Borchers, London, 1897, p. 111.

make very close calculations of dimensions because of the unknown factors which enter into the actual working of the furnace; but time is saved and results more quickly obtained by making approximations to the theoretical conditions.

A furnace actually built at the FitzGerald and Bennie Laboratories for certain experiments is shown in elevation, partly sectional, in Fig. 2, and a plan of the same furnace in

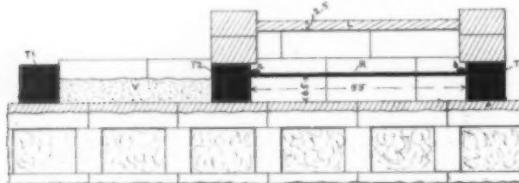


FIG. 2.—SECTION OF FURNACE.

Fig. 3. In the plan the covering tiles and bricks are removed. All dimensions are given in centimeters. T_1 is the terminal of the granular carbon regulating resistor V , T_2 the terminal common to the regulating resistor and the furnace, T_3 the other terminal of the furnace. R is the furnace resistor, a and b two carbons which pass through the side wall of the furnace, and can be connected to a voltmeter. The furnace is built on a fire-brick base of cellular structure, and the cells filled with a suitable heat insulator. The top of the furnace is covered with the tile L , and this in turn should be covered with a heat insulator. As shown in Fig. 2, R is connected to the terminals T_2 and T_3 by introducing its ends into the holes of larger diameter in the terminals and packing the space between the rod and the inner surface of the holes with graphite. This method of connection is found to give very satisfactory results, as it takes care of the contraction and expansion of the rod accompanying variations in temperature.

The voltmeter carbons a and b have a circular cross section, and the ends resting on R are filed to a concave surface cor-

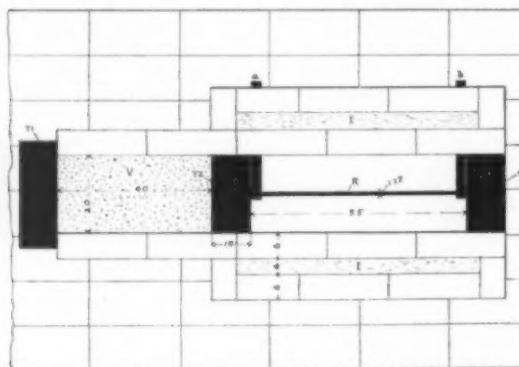


FIG. 3.—PLAN OF FURNACE.

responding to the curvature of R . The total length of R is about 60 cms., the effective part, that is the part between a and b , is about 52 cms. long.

The figures show the furnace as it was actually built; but for permanent work, or where it was desired to build as efficient an apparatus as possible, certain changes would be made. Thus the voltmeter carbons a and b ought to be of smaller diameter than the resistor, for with the large sized carbons actually used there is much loss of heat by conduction. The terminals also should be much smaller than those shown, and should be made of amorphous carbon, in order to avoid unnecessary loss of heat. It will be seen later that the loss of heat at the ends of the resistor was very great.

In the furnace, the resistor R was made of graphite, so that its resistivity may be assumed to be 0.00076 ohm. Then the resistance between a and b would be

$$\frac{55}{0.00076} = 0.033 \text{ ohm}$$

1.27

Actually the minimum resistance observed was 0.0325 ohm, but as the distance between a and b was only roughly measured, this is very close to the calculated quantity.

The furnace was constructed originally for the purpose of studying the behavior of this type, and was used for making a silica tube. After it was built, as shown in the figures, it was filled with pure quartz sand, which completely surrounded R . Two runs were made on consecutive days, the furnace thus having plenty of time to cool between the first and second runs. The power curves of the two runs are shown in Fig. 4.

Taking the two curves together, the mean ordinate is found to be 4.2 kilowatts, therefore the total power used was 5.0 kilowatt hours. Taking the mean value of the energy de-

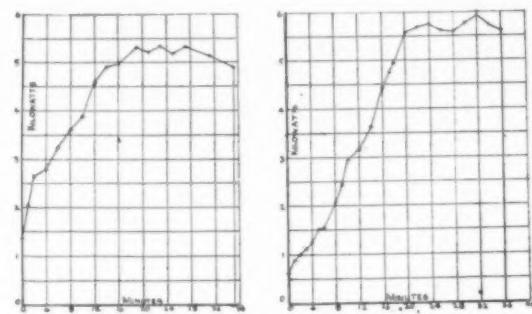


FIG. 4.—POWER CURVES.

veloped in the resistor, it is found that the average watts per square decimeter of resistor surface were 1.9 kilowatts. The maximum load was 5.9 kilowatts, that is, approximately 2.7 kilowatts per square decimeter.

After the furnace had cooled, following the second run, the resistor was removed from the furnace and was found to be surrounded with a fused quartz tube as shown in Fig. 5. In Fig. 6 is a sectional view of the quartz tube and the resistor. The maximum exterior diameter of the quartz tube was 6 cms., and its length 52 cms. It weighed 1.54 kilograms. It will be observed in Fig. 5, that the ends of the tube taper off, showing the cooling effect of the terminals and the voltmeter rods. Fig. 6 shows how the fused tube has shrunk away from the resistor. By measurement it is found that the average diameter of the interior of the tube is 2 cms.

The temperature to which the tube was heated must have been very high, for taking the inside diameter of the tube it is found that with the maximum kilowatts of 5.9, there were 1.8 kilowatts per square decimeter of the inside surface of the tube. This must have produced a very high temperature in

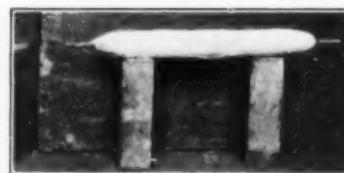


FIG. 5.—FUSED QUARTZ TUBE.

the interior of the tube, and judging by its appearance the silica must have been raised to its boiling point. Through an accidental occurrence an approximation to the temperature of the tube was obtained. Some small pieces of coke dropped into the sand used in the experiment, and one piece was found in a small cavity, near the outer surface of the quartz cylinder, about 2.5 cms. from its axis. Here, when the maximum kilowatts were developed, there were only 690 watts per square decimeter, yet the grain of coke was covered with crystals of silicon carbide.

Whatever was the actual temperature in the tube, it cer-

tainly was very high, and therefore there was a very rapid vaporization of the silica, and the vapor produced reacted with the carbon of the resistor, forming silicon carbide. Careful measurement showed that this did not appreciably alter the diameter of the resistor, the silicon carbide apparently taking the place of the carbon on the outside of the resistor. A fair-sized piece of the resistor was heated in oxygen to remove all



FIG. 6.—QUARTZ TUBE AND RESISTOR.

free carbon, and the residue was found to consist of silicon carbide. The carbide at the outer part of the resistor was left in the form of a solid ring (Fig. 7) or cylinder with an average thickness of 1 mm., while the carbide from the interior of the resistor was in the form of powder. The ash in the carbon amounted to 7.3 per cent, while in the original resistor it was only 0.09 per cent.

The approximate amount of silica vaporized from the interior of the tube and combined in the carbon as silicon carbide may be calculated from the figures given above. The total weight of the resistor affected amounted to 108 grams, and from the analysis it is found that the silicon carbide present amounts to 7.88 grams, corresponding to 11.8 grams of silica. This phenomenon of the vaporization of silica and formation of silicon carbide is important, since it has a marked effect on the resistance of the resistor. Thus, at the end of the first run, the resistance of R was 0.037 ohm, and at the end of the second run was 0.041 ohm.

As was pointed out before, the furnace described above must not be taken as a model of design, for it was not built with that end in view. The shape of the silica tube showed the serious heat losses caused by faulty design. The illustration must therefore be merely considered as giving some notion of the working of a Borchers furnace.

It will be readily seen that a serious objection to a furnace built with a solid resistor as described above is the low resistance of the solid carbon resistor, which involves the use of heavy currents of low voltage if large amounts of power are required. This objection may be illustrated by some simple calculations.

Let it be assumed that we have at our disposal a 5-kilowatt transformer giving a current of 200 amperes at 25 volts. Then if it is desired to use 5 kilowatts in a furnace of the kind described above, the resistance of the resistor must be

$$\frac{25}{200} = 0.125 \text{ ohm}$$

If the resistor has a working resistivity of 0.00076 ohm, then we have

$$\frac{1}{0.00076} = 0.125 \quad (1)$$

A

where 1 is the length and A the sectional area of the resistor, and from (1) we find that the ratio between the length and sectional area is

$$\frac{1}{A} = 164 \quad (2)$$

This plainly would necessitate very poor furnace design, as the length of the furnace would be enormously greater than its width or depth, and it has been shown elsewhere, that the nearer a furnace of rectangular shape approaches a cube in its dimensions the greater the efficiency, because in this way the radiation of heat from the outside of the furnace is reduced to a minimum.

But in addition to this question of design, there are other considerations which are fatal to the construction of the furnace if we attempt to use a graphite rod as resistor. Let it be assumed that to carry out the furnace work, we require 2.5 kilowatts per square decimeter of resistor surface. Then if the length of the resistor is l, as before, and the radius of the resistor is r, we have the following equations to determine its dimensions. To fulfill the requirements as to resistance equation (2) becomes

$$\frac{1}{\pi r^2} = 164 \quad (3)$$

and the equation for the surface is $a =$

$$\frac{5000 \times 100}{2\pi r l} = 2500 \quad (4)$$

From (3) and (4) we find

$$l = 80.5 \text{ cms.}$$

$$2r = 0.79 \text{ cms.}$$

While carbon rods of these dimensions might be obtained, they would be found very unsatisfactory, for they would be too delicate to handle without breaking.

A closer approach to a practicable resistor might be made by using one having a rectangular cross-section, for this shape would give a greater heating surface for the electrical resistance of a given length. Assume, for example, that we de-



FIG. 7.—OUTER PART OF RESISTOR.

cide to use a plate 0.3 cm. thick. Then if the width of the plate is b, equations (3) and (4) may be written as follows:

$$\frac{l}{0.3b} = 164 \quad (4)$$

$$\frac{5000 \times 100}{2(0.3 + b)l} = 2500 \quad (5)$$

From (4) and (5) we get

$$l = 62.5 \text{ cms.}$$

$$b = 1.27 \text{ cms.}$$

This is somewhat better, but the plate would be a very delicate article to handle, and even if successfully put in place in the furnace, would probably be broken while in use.

Some examples of improved forms of resistors are shown in Fig. 8. These may easily be made from graphitized articles with the help of a hack-saw. The forms shown in the figure have been made and used in the laboratory for various purposes and were found to give satisfactory results. It should be noted here that in connecting the resistors having a rectangular cross-section to the terminals a good method is to cut slots in the latter, the dimensions of the slots being greater than those of the section of the resistor. The ends of the resistor are then put in the slots, and the empty spaces tightly packed with graphite.

The advantage of using resistors made on these principles is obvious, overcoming as they do the difficulties considered

above. Take for example the middle resistor shown in Fig. 8. Calculating the ratio between length of the resistor as regards its electrical resistance and the length in a straight line, we find it to be 2.4; that is, if the distance between terminals is 10 cms., the effective length of the resistor so far as electrical resistance is concerned, is 24 cms. In this way the difficulty of impracticable length needed to obtain a given rate of energy-expenditure with a given heating surface is avoided.

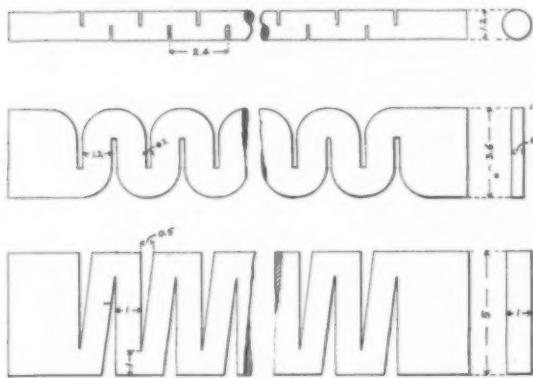


FIG. 8.—IMPROVED FORMS OF RESISTORS.

For example, assuming the same conditions as before: 5 kilowatts, with 25 volts and 200 amperes, we have

$$\frac{I}{0.00076} = \frac{25}{0.5 \times 1.2 \times 200}$$

$$I = \frac{99}{2.4}$$

$$I = 41 \text{ cms.}$$

Denoting the distance between terminals by L, we have

$$L = \frac{99}{2.4}$$

$$= 41 \text{ cms.}$$

Finally the watts per square decimeter of heating surface would be approximately 2,500 as required.

In cases where it is desired to work at a lower resistor temperature, using less watts per square decimeter, another form of resistor shown in Fig. 9 may be advantageously used. This is a cylinder which will take approximately 400 amperes with 10 volts, and treating the carbon as though it were not cut, as shown, will give about 1,000 watts per square decimeter. Another obvious method of treating hollow cylindrical resistors so as to increase the resistance per unit of length is to cut a helical slot in the cylinder, thus forming a helical resistor.

Sometimes it may be desirable to introduce gases into a furnace while it is working, and for this purpose a resistor of the form shown in Fig. 9 is suitable. In making connection



FIG. 9.—RESISTOR.

to one of the terminals by the method already described, the hole drilled in the terminal is carried all the way through and suitable connection made to the gas tank or generator.

In using resistors of the kinds described above, it may be objectionable to have the furnace charge get into the spaces between the sections of the resistor. In that case the spaces may be filled with agglomerated charcoal powder, which is a non-conductor, compared with the resistor material. Before

using the charcoal for this purpose it should be ignited at a very high temperature to remove all shrinkage. A satisfactory agglomerating material is a strong solution of sugar. It is a good plan to use this charcoal in any case where, for example, the resistor is like the lowest one shown in Fig. 8. Unless this resistor is handled carefully it is likely to break, but if the V-shaped spaces are filled with the agglomerated charcoal, it makes a pretty strong article.

Sometimes in making experiments with a Borchers furnace it may be important to avoid contact between the carbon resistor and the charge. Thus in reducing the oxides of some metals the metal when set free may attack the carbon resistor if in contact with it. In this case the charge may be heated by radiation from the resistor. A furnace used for this purpose is shown in Fig. 10. The resistor used here is of the third form shown in Fig. 8. With a distance of 50 cms. between

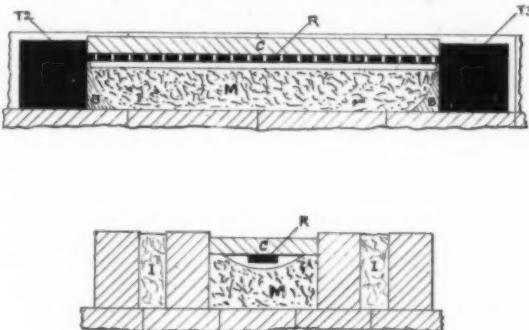


FIG. 10.—FURNACE WITH RADIATION OF HEAT FROM RESISTOR.

terminals, this resistor would take a current of about 260 amperes with 40 volts. In the Figs. T₂ and T₃ are the terminals of the furnace; R, the resistor; M, the charge which is insulated, form the terminals by the granular charcoal B. The resistor is covered with a slab of heat insulator, not shown in the drawing. The lower drawing in the figure shows a transverse section of the furnace. The V-shaped spaces in the resistor should be filled with agglomerated charcoal to strengthen the carbon, which otherwise would certainly get broken by its own weight.

Electrometallurgy of Iron and Steel before the Faraday Society.

In our December issue, 1904, we covered very fully the important report of the Canadian Commission which studied European industrial developments in the electrometallurgy of iron and steel. Some new interesting information is given by Mr. F. W. HARBORD, who was the metallurgical expert of that Commission, in a recent paper presented before the Faraday Society in London. In the following we give those portions of Mr. Harbord's paper which contain new information:

The author first described the Kjellin induction furnace (our Vol. I, pages 70, 141, 283, 376, 462, 526, 576; Vol. II, page 479) and mentioned that Mr. Kjellin has sent him particulars of recent developments in a letter dated January 7, 1905, which is as follows: "Having at last got a new turbine, we are able to increase the power at the furnace to 175 kilowatts (239 electric hp) instead of the maximum being 165, and this increase of power, together with a diminished area of contact between steel, masonry and slag, has increased the output of the furnace from 4 tons to from 5.2 to 5.5 tons in twenty-four hours, which naturally makes the melting costs lower. Another reason for these good results is that, owing to some slight alterations, I have got the power applied more uniformly over the whole time of the charge. In future I shall be able to build the

furnaces so that they shall consume the maximum power of the turbine or engine all the time. I have already done so in the case of small trial-furnace, put up last summer in the south of France. The capacity of the Gysinge furnace with 175 kilowatts is now 1450 kilograms, of which 900 kilograms are tapped each time. I have recently used pig and ore instead of pig and scrap, and this seems to answer very well. The ore used is briquettes from Herrang concentrates, containing about 70 per cent iron, and consequently practically no gangue, so that the wear and tear is not increased to such an extent as would be the case if the ore contained much gangue. The briquettes being very low in phosphorus, I can in this way get a high quality steel cheaper than by using scrap and pig, though the production of the furnace is only 60 to 65 per cent of the production from cold scrap and pig. If using molten pig and ore I should get the same output from a given power as from cold pig and scrap, but the waste would be much lower, as the iron of the ore would be almost perfectly reduced."

It will be seen from the above that pig and ore can be used in the furnace, but to obtain a high-class product, none but extremely pure materials can be employed, and at present Swedish materials are probably the only suitable ones which are available. The furnace in its present form can only be used for the manufacture of tool and other high-class steels, and in the majority of cases, at all events outside Sweden, it will probably pay better to use pig and scrap only, as the saving effected by ore and pig, when the reduced output is considered, cannot be very great.

The author then discussed the Héroult process (our Vol. I, page 63, 287, 449, 461, 467; Vol. II, page 408, 481), and makes a comparison between the processes of Kjellin process and the Héroult process. He thinks that as they are now being worked, there is very little difference between them in the cost of operation. The chief point, however, when one process has an advantage over the other, is in the cost of raw material. The Kjellin process, to produce the highest class tool steel, is limited to the best Swedish scrap and the best Swedish pig, or pig and ore, whereas common miscellaneous scrap is the raw material used in the Héroult process. In Sweden this high-class scrap can be obtained at a comparatively low figure, but in other countries, Walloon scrap, if obtainable at all, which is not likely, would cost probably \$60 per ton, and possibly more, and it would most likely be necessary to buy the Walloon bars at the same price as bars for cementation. On the other hand, ordinary steel scrap in England can be bought from \$12.50 to \$15 per ton, so that in countries outside of Sweden the Héroult process has a great advantage. It is quite possible that Mr. Kjellin may be able to modify his furnace, so that he can renew his slag, and thus effect purification in the same way as in the Héroult process, but in its present form it is limited to the purest material either as scrap or scrap pig ore. His latest results with pure ore have no doubt reduced the costs, but the Héroult process still has a great advantage as regards the raw materials.

In the present stage of development, neither type of furnace can be regarded as a competitor to either the Siemens or the Bessemer processes for the production of rail and structural steel, and they can only compete successfully in the production of high-class crucible steel or steels for ordinance and other special purposes made in the Siemens furnace. In cases where very large steel castings are required of crucible steel quality, several electric furnaces, working so that they could be tapped into a common receptacle, before pouring the steel into the mold, should give excellent results and be much more economical than the crucible process. Under favorable conditions electric energy might compete with gas as regards cost, but until it is possible to use furnaces of from 30 to 40 tons capacity, the extra labor charges inseparable from small furnaces will prevent them from holding their own against the Siemens or Bessemer process.

"So far as the steel works engineer is concerned, there is

no difficulty in designing a furnace of any size required, as furnaces, very similar in general design to the Héroult furnace, holding 200 tons of molten steel, are at present working both in England and America, and it only remains for the electrical engineer to arrange for the electrical heating without unduly weakening the roof or other parts of the furnace. Provided this can be done, under favorable conditions, where electric energy is so cheap that it can compete with producer gas as a heat producer, there is not the least reason why the present 5-ton electric furnace should not develop into a 40 or 50 ton furnace, in the same way that the 5-ton ordinary Siemens furnace has developed during the last twenty-five years."

Mr. Harbord then gave a review of the experiments made at Livet on the reduction of pig iron from the ore (our Vol. II, page 483) in the electric furnace. He mentioned briefly the manufacture of ferro-alloys at Livet, as follows: The furnaces used were identical with those employed in the pig-iron experiments, and the only difference was in the alteration of the furnace mixture, and in the regulation of the electric current to obtain the necessary heat required for the particular operation. Ferro-chromes from about 45 per cent to 60 per cent, and ferro-silicons from 25 per cent to 80 per cent, were being made regularly, although 50 per cent ferro-silicon was the alloy that they were making most largely at this particular time. In the manufacture of this alloy, a very intense temperature is necessary to obtain a good tapping heat, and it is desirable to work with as little flux as possible, so that a very small quantity of slag is produced. The alloy is tapped into horizontal molds holding about 2 cwt., and the little slag formed is raked off the surface of the alloy before it solidifies. In the manufacture of these alloys, oxide of iron is not used as the source of iron, but selected steel scrap. In the case of chrome-alloys it is desirable to use rich chrome iron ore. The demand of these alloys undoubtedly increasing, many steel foundries using nothing below 25 per cent to 30 per cent ferro-silicon, and some nothing below 50 per cent. The increasing demand for chrome and tungsten alloys for the manufacture of the various special steels required for ordinance and other purposes is too well known to need comment.

Up to about 12 per cent to 15 per cent ferro-silicons, and 40 per cent ferro-chrome, the blast furnace is probably a more economical metallurgical appliance than the electric furnace, but for higher alloys the latter holds the field.

Mr. Harbord finally passed over to the Stassano arc furnace (our Vol. I, page 247) and quoted from a letter of Stassano dated January 15, 1905, the following particulars of recent developments in the Stassano furnace now employed for scrap melting and purifying at the government works at Turin. The furnace is almost entirely charged with scrap or a mixture of scrap and pig-iron, so that the original intention of Stassano to make steel from iron ore in one process has been abandoned. The letter of Stassano reads as follows:

"The furnace at Turin has been working regularly since March last, producing normally the grade of steel required by the government for the manufacture of artillery projectiles. The furnace is standing at present, in consequence of the transformer having been damaged, but a new one is being installed which will reduce the current from 3000 to 80 volts; the furnace is expected to be ready to commence work again in March.

"The usual charge consists of 350 to 400 kgs. of pig iron, 200 to 250 kgs. of scrap, the necessary amount of ore being added to oxidize the impurities, and sufficient lime to form a basic slag to protect the lining of the furnace and remove the phosphorus and sulphur in the material employed. During the last year's working the following data have been obtained: Loss on weight of materials charged 1.5 to 2.01 as a maximum; consumption of electrodes, 5 kg. per ton of steel produced; mean consumption of current 1.2 kw. per kg. of steel

produced, equal to .186 ehp-year per ton of steel; six men, an electrical mechanic, melter and four laborers are more than sufficient for one furnace."

* * * * *

Concerning the presentation and discussion of this paper, which had attracted the largest attendance of members and visitors which have been present at any meeting of the Faraday Society, our special London correspondent writes as follows: The paper was not read. Instead, Mr. Harbord lectured on the subject with the illustration of some scarcely distinguishable lantern views. Some lantern slides showing views of the works at La Praz, sent by M. Adolphe Minet, could not be shown to the meeting by reason of the fact that lantern slide dimensions are not internationally standardized. Some samples of Héroult steel, and some pieces of ferro-silicon, ferro-chrome and ferro-tungsten, all sent by M. Minet, evoked much interest.

The discussion was opened by Mr. Morrison, who testified to the accuracy of Mr. Harbord's conclusion as to the energy required for the direct smelting of the ore, his own experiments agreeing almost identically with Mr. Harbord's figures. He also endorsed Mr. Harbord's view that the electric furnace, even under English conditions, is a cheaper producer of high-grade steels than the crucible furnace. As to the cost per electrical horse-power year, he thought £4 would represent the cost with water power, and £7 to £8 for steam-driven plants. So far as the commercial possibilities of the case went, the Héroult, Keller, and perhaps the Kjellin furnaces were commendable—the rest might be eliminated as merely theoretical. Mr. Morrison disagreed in one respect with the writer of the paper, and that lay in the view that the production of structural steel electrothermically was possible. This view was based on some new information sent by M. Héroult, who was now putting down a 50-ton electric furnace, together with a mixer to hold 300 tons of steel. Also starting with ore only, the latest figures showed a consumption of 0.15 electrical horse-power year per long ton of steel, or starting with molten metal 0.05 electrical horse-power year. Mr. Morrison therefore looked forward to the use of the Héroult furnace in England.

Mr. Hutton was inclined to regard the whole question as in too early a stage for the passing of a definite verdict. In any case the Kjellin furnace did not seem technically good, or likely to be economical. The temperature of the smelted metal was likely to be low, an important matter with low carbon steels. Personally, he favored the electric treatment of an already-heated metal, and urged the trial of the electric furnace as an adjunct to the ordinary blast furnace. A combination of large gas engines using furnace gas, directly coupled to large electric generators, would probably be a feature of the first English experiments. With regard to Mr. Harbord's calculations of the cost of the amount of power required, had the effect of long stoppages on the cost been considered? Mr. Harbord had referred to the value of water-cooled electrodes, his (Mr. Hutton's) experiences with these had been very favorable, indeed he had been able to melt platinum wire within 2 inches of the water-cooled part of the carbon tube.

Mr. R. L. Gamlen (of the Lancashire Electric Power Company) dealt with the subject from the point of view of a supplier of energy in bulk. A single huge furnace would involve large fluctuations in the demand for power—perhaps several smaller furnaces might be so worked in alteration as to give a load factor approaching 100 per cent.

At the suggestion of the chairman, Dr. Perkin, Mr. Harbord intervened to meet the remarks of the previous speakers. He held to his views regarding the commercial production of structural steel chiefly by reason of the cheapness and efficiency of the 50-ton Siemens furnaces, wherein the cost of producing ingot steel from molten pig was only 12s. 6d. per ton. He had estimated the cost of power in England at £10 per

electrical horse-power year, this being the quotation of a large municipality for a 2,000 kilowatt undertaking, and would be glad if any engineers present could assure him of cheaper power. Of course the use of several furnaces would equalize the load. While he had advocated the separation of the blast furnace from the electric steel furnace, he had done so with a mental reservation in favor of the interposition of the ladle and traveling crane to connect the steel furnace with the blast furnace.

Mr. Gamlen responded to the invitation by offering power at £7 per electric horse-power year for 24 hours a day. If, however, its use could be confined to the 12 hours of the night, the charge would be about £4 per electric horse-power per year of 365 days. This being obviously impossible, the discussion was continued by Dr. Steinhart, who spoke of the inherent conservatism of the Sheffield manufacturer as the chief obstacle to the adoption of the electric furnace. With regard to arc furnaces, was not the carbon from the electrodes likely to contaminate the steel? Could the electric furnace give a guaranteed percentage of carbon? Mr. Hughes then congratulated the authors on having set out the essentials of the question without inflation, which had been so disastrous to electricity in England in the early years of the secondary battery. Letters were read from Mr. B. H. Thwaite, and from Mr. Bertram Blount, which were generally very favorable in the views entertained as to the commercial prospects for England.

In proposing a vote of thanks to the author, Dr. Perkin spoke of the industrial importance of such matters, and the need for experiment. Above all, the British manufacturer needed to be technically educated. In Mr. Harbord's reply, which concluded the meeting, the chief point of interest lay in his pointing out that the only unstopped source of fuel—the cheapness of which was so manifestly important—lay in the extensive use of blast furnace gas.

Materials Used in the Construction of Filter Presses.

BY EMIL HATSCHEK.

When designing plant or appliances for the chemical manufacturer, the engineer is often confronted with a difficulty which rarely presents itself in his other work: the difficulty that the materials on which he is accustomed to rely—practically three, cast iron, steel and gun metal—are unsuitable. The substance to be handled may either attack these materials so rapidly as to impair their strength in a short time, or, if their action is not quite so energetic, the presence of even small amounts of iron, etc., in the finished product, may be objectionable. This difficulty may be aggravated by mechanical conditions, as in the case of filter presses, when the apparatus is exposed to considerable pressure, and by the obvious impossibility of using the materials on which the chemist relies in the laboratory, namely, glass and platinum.

Notwithstanding these limitations, it has been found possible to construct filter presses suitable for practically all technical purposes, and as the various expedients adopted are not perhaps generally known to manufacturers, a brief description of the materials available and employed in filter press construction may be of interest, and may lead to the adoption of this very useful appliance in cases where some apprehension as to the possibility of using a suitable material has hitherto prevented its introduction.

Where no objection exists to its use, iron is, of course, the material generally used for filter press plates and frames. The large majority of makers employ cast-iron plates, either directly supporting the filter cloths, or covered with perforated steel plates, which give a better support to the cloths and prolong their life. The Niles-Bement-Pond Company have lately introduced a rather radical departure, by building up their

plate from a corrugated steel panel and a cast-iron frame. This type was described in the issue of December, 1904, of this journal. The only possible objection to the use of steel is that it is more readily attacked by some liquors than is the skin of cast-iron plates, and that steel in contact with the cast iron sets up electrolytic action.

The fittings on iron presses, viz.: the outlet cocks for the

machine is used for white lead and holds about 3000 pounds at a charge. The plates and frames are made of Georgia pine, and are bolted together with steel bolts, painted with asphaltum paint. The feed inlet is fitted with a gun metal liner, while the inlet for the wash water, as well as the outlet for the washings, are provided with hard rubber liners and cocks—these passages being subject to a slight pressure only.

The outlet cocks on the plates are also made of hard rubber. The filtrate is discharged into a wooden trough. It may be worth mentioning that the press is provided with a special distance piece, which allows the press to be opened to the unusual extent of 4 feet, so that the frames may be tipped into a horizontal position, and the cake, which is very sticky, be discharged readily.

The presses just described answer for all organic and for dilute inorganic acids, but

even concentrated sulphuric acid does not present an insuperable difficulty, as it is possible to construct filter presses of lead. The plates are either cast of regeline lead round a core of steel plate, which gives the necessary strength and rigidity, or cast-iron plates coated with lead are used. It will thus be seen that there is practically no substance requiring to be filtered on a commercial scale for which a suitable filter press cannot be made.

filtrate and the cloth unions, are generally made of bronze or brass, to prevent rusting or the possibility of sticking. When these materials cannot be used, e. g., with alkaline or cyanide solutions, these parts can easily be made of cast iron, steel or malleable iron.

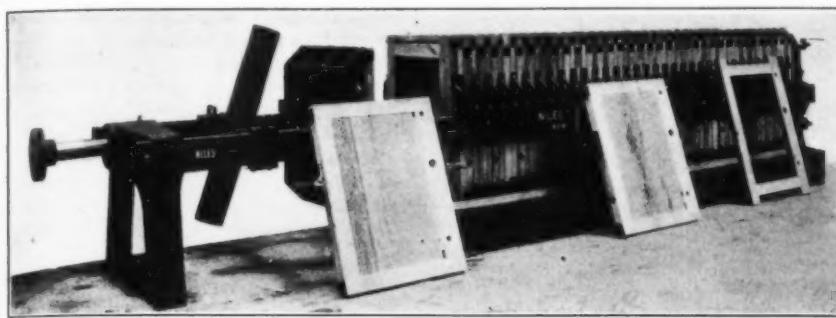
In a large number of cases, however, iron cannot be used, either because the liquor to be filtered is acid, or because it is absolutely essential to preclude any possibility of contaminating the solid matter by iron oxide, e. g., with barytes, blanc fixe, china clay, etc. These requirements may be met by making the plates and frames of the press of an alloy or metal not attacked by the acid, such as gun metal, phosphor bronze or aluminium, or else of wood.

Gun metal presses, when they can be used, have the advantage of great strength and of being suitable for hot liquors, but their cost is very considerable. The frame work of the press is always made of iron, with gun metal liners in all passages for the liquor. In spite of their high price, gun metal presses have found a good deal of use in special cases: in England, for instance, gun metal presses 18 inches or 24 inches square, with frames 2 inches deep, are used by most of the white lead manufacturers.

When the cost of the machine or the nature of the liquid precludes the use of metal, recourse is had to the wooden filter press. This machine has plates and frames built up from a number of suitable pieces. The design is slightly modified from that of metal plates, to suit the exigencies of the material. The wood employed is pine, which is particularly suitable on account of its resinous nature, oak, or maple, and the writer has even found it possible to use white poplar, if impregnated with a heavy hydrocarbon. The bolts holding the plates and frames together are generally steel bolts, painted with asphaltum paint, but they, as well as the screws fastening the handles to the wood, can be made of bronze at little extra cost. If individual outlet cocks on all plates are used, these are often wooden faucets, but they are not very satisfactory for washing presses, on which they are exposed to the full pressure of the wash water, and are liable to leak. Hard rubber cocks answer very well in these cases.

The frame work of the press is, of course, iron, and similar to that of iron machines. As all passages for the liquor, washings, etc., are formed in the iron head, it is necessary to provide them with suitable liners. Gun metal, lead, tin or hard rubber pipe may be used, and one or the other of these materials will answer in most cases.

A large wooden press, in which most of the available materials have been drawn upon, is illustrated in Fig. 1. The



LARGE WOODEN FILTER PRESS.

METALLURGICAL CALCULATIONS.—IV.

BY J. W. RICHARDS, PH.D.

Professor of Metallurgy in Lehigh University.

THE ELDRED PROCESS OF COMBUSTION.

A means of regulating the temperature of the flame has been proposed by Eldred, and described by Mr. Carlton Ellis in the December, 1904, issue of this journal. The proposition is simply to mix with the air used for combustion a certain proportion of the products of combustion themselves. The principle is easily understood when the requisite calculations of the theoretical flame temperatures are made. When solid fuel is burnt the temperature is often too high locally, and results in burning out grate bars or overheating the brick work of the fire-place, or overheating locally the material which is mixed with the fuel. If the air is diluted with products of combustion the initial theoretical temperature is lowered, and the above evils may be obviated. Using solid fuel, the heat in the fuel before the air actually burns it must be added to the heat generated by combustion to get the actual temperature in the hottest part of the fire.

Examples: (1) What will be the highest temperature in a charcoal fire fed by air, assuming complete combustion without excess of air?

Assuming the charcoal to be pure carbon, and to be heated to the maximum temperature t before it burns (by the combustion of the preceding part), the heat available is:

Heat of combustion of 1 kilo of carbon..... 8100 Cal's.

Sensible heat in the carbon at t° 0.5t - 120 "

Total heat available to raise the temperature $7980 + 0.5t$ "

Products of combustion..... CO² 1.85 m³

N² 8.89 "

Heat of product at t° CO² 1.85 (0.37t + 0.00027t²)

N² 8.89 (0.303t + 0.00027t²)

Sum $3.378t + 0.00074t^2$

therefore $3.378t + 0.00074t^2 = 7980 + 0.5t$
whence $t = 1872^\circ$

(2) What will be the temperature in the same case, if the air used is diluted with an equal volume of the products of combustion?

The heat available is the same as before, $7980 + 0.5t$; but since the mixed air for combustion contains only half as much oxygen per cubic meter, the products will be exactly doubled in amount for a unit weight of carbon burnt, and we therefore have directly

$$2(3.378t + 0.00074t^2) = 7980 + 0.5t \\ \text{whence } t = 1026^\circ$$

It is therefore evident that the maximum temperature of the hot gases at their moment of formation is nearly halved by the procedure stated.

(3) Taking the cases cited by Mr. Ellis, where the products contained originally 15 per cent oxygen and 6 per cent carbon dioxide, and after mixing the air used with half its volume of the chimney gases, 9 per cent oxygen and 12 per cent carbon dioxide (the gas-air mixture entering containing 15 per cent oxygen and 6 per cent carbon dioxide), what are the maximum temperatures obtained in the two cases?

Case 1: The heat available is as before; the products of combustion are $\text{CO}^2 1.85 \text{ m}^3$, $\text{O}^2 4.62 \text{ m}^3$, $\text{N}^2 24.36 \text{ m}^3$, and their sensible heat at temperature t —

$$\begin{array}{rcl} \text{Heat in CO}^2 & = & 1.85 (0.37t + 0.00027t^2) \\ " \quad \text{O}^2 + \text{N}^2 & = & 28.98 (0.303t + 0.000027t^2) \end{array}$$

$$\text{Sum} = 9.46t + 0.00128t^2$$

$$\text{therefore } 9.46t + 0.00128t^2 = 7980 + 0.5t \\ \text{whence } t = 800^\circ$$

Case 2: The products, per kilogram of carbon burnt, will be $\text{CO}^2 3.70 \text{ m}^3$, $\text{O}^2 2.77 \text{ m}^3$, $\text{N}^2 24.36 \text{ m}^3$, and we have

$$\begin{array}{rcl} \text{Heat in CO}^2 & = & 3.70 (0.37t + 0.00027t^2) \\ " \quad \text{O}^2 + \text{N}^2 & = & 27.13 (0.303t + 0.000027t^2) \end{array}$$

$$\text{Sum} = 9.09t + 0.00173t^2$$

$$\text{therefore } 9.09t + 0.00173t^2 = 7980 + 0.5t \\ \text{whence } t = 764^\circ$$

Conclusions: The calculations regarding the Eldred process bring out what was not stated in the printed description of the method, viz.: that if a small excess, or no excess of oxygen escapes, to the chimney, the temperature of the flame will be greatly reduced by the dilution of the air used, because more gas-air mixture will be required per unit of fuel burnt; but if there is any large amount of unused oxygen escaping in the first instance, the dilution practiced will scarcely affect the temperature of the flame at all, because it makes very little difference whether the fuel is heating up unused oxygen or carbon dioxide dilutant substituted for some of it, as long as there is more than enough oxygen to burn the fuel. The fact of the specific heat of carbon dioxide being greater than that of oxygen, is the only reason for the small calculated difference of 36° , in cases 1 and 2. It is true that the dilution practiced will result in less heat being lost in the waste gases, in the *Example* (3), but the same economy could be obtained by simply using less excess of air in the first instance.

TEMPERATURES IN THE "THERMIT" PROCESS.

The Goldschmidt process of reducing metallic oxides by powdered aluminium, igniting the cold mixture, is only a special case of our general rule, as far as concerns the calculation of the theoretical temperatures obtained. In any case, the total heat available is the surplus evolved in the chemical reaction, and the temperature sought is that to which this quantity of heat will raise the products of the reduction. The products are alumina and the reduced metal. The heat in the latter, in the melted state, is well known in many cases; it is most clearly expressed by the sum of the heat in such melted metal just at its melting point (which is easily de-

termined calorimetrically, and is well known for many metals), plus the heat in the melted metal from the melting point to its final temperature, which is equal to t , minus the melting temperature, multiplied by the specific heat in the melted condition. These data are known for many metals; for some they may have to be assumed from some general laws correlating these values. The heat in melted alumina has not been determined calorimetrically, to my knowledge. Its sensible heat solid is $0.2081t + 0.0000876t^2$ (determination made in author's laboratory), which, evaluated for the probable melting point, 2200° C. , would give the heat in it at that temperature 881.8 Calories ; the latent heat of fusion of molecular weight is very probably $2.1T$, where T is the absolute temperature of the melting point, making the latent heat of fusion per kilogram $2.1(2200 + 273) \div 102 = 5193 \div 102 = 50.9 \text{ Calories}$. The specific heat in the melted state is probably equal to the specific heat of the solid at the melting point, viz.: $0.2081 + 0.0001752 (2200) = 0.5935$. We, therefore, have for the heat in melted alumina at temperature t —

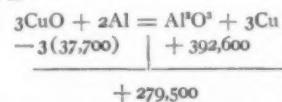
Heat in solid alumina to the melting point....	881.8 Calories
Latent heat of fusion.....	50.9 "
Heat in liquid alumina to its setting point....	0.5935 ($t - 2200$)

Total $932.7 + 0.5935(t - 2200)$
or, for a molecular weight, 102 kilograms: $95.135 + 60.54(t - 2200)$.

Examples:

(1) If black cupric oxide is reduced by powdered aluminium, what is the temperature attained?

The reaction is



The products must therefore be raised to such a temperature that they contain 279,500 Calories. The heat in molecular weight of alumina at temperature t has already been found; that in copper at t° is, for one kilogram (using the author's determinations):

Heat in melted copper at setting point = 162 Calories.

Heat in melted copper above $1065^\circ = 0.1318 (t - 1065)$ Calories.

Total = $162 + 0.1318 (t - 1065)$.

Per atomic weight (63.6 kilos.) = $10303 + 8.3825 (t - 1065)$.

From these data there follows the equation:

$$95.135 + 60.54(t - 2200) + 3[10303 + 8.3825(t - 1065)] = 279,500 \\ \text{whence } t = 3670^\circ$$

A little further calculating will show that approximately one-third of all the heat generated exists in the copper, and two-thirds in the melted alumina.

(2) If pure ferric oxide is reduced by the "Thermit" process, what is the temperature of the resulting iron and melted alumina?

The reaction and the heat evolved have been already given in the preceding instalment of these calculations. (q. v.). They show that per molecular weight of alumina formed there are two atomic weights (112 kilos.) of iron formed, and there is disposable altogether 197,000 Calories. The heat in a kilogram of pure iron at its melting point (1600°) is 300 Calories, the latent heat of fusion approximately 69 Calories, and the specific heat in the melted conditions 0.25. The total heat in a kilogram of melted iron is therefore $360 + 0.25(t - 1600)$ Calories, or per atomic weight = $20,664 + 14(t - 1600)$ Calories.

We, therefore, can write the equation:

$$95.135 + 60.54(t - 2200) + 2[20,664 + 14(t - 1600)] = 197,000$$

$$\text{whence } t = 2694^\circ$$

A similar calculation made for the reduction of MnO by the

theoretical amount of aluminium, shows a reduction temperature less than the melting point of alumina. This would mean that the melting down of the mass to a fused slag of pure alumina could not take place. What happens in the reduction of manganese is that an excess of manganese oxide is used, whereby all the aluminium is consumed, and none at all gets into the reduced manganese, and, furthermore, the excess of manganese oxide unites with the alumina to form a slag of manganese aluminate, which is fusible at the temperature attained. Without the latter arrangement no fused slag could result.

Similar calculations, made with silicon as the reducing agent, show similar difficulties regarding the theoretical temperatures attainable, when iron or manganese are reduced. By using an excess of the oxides of these metals, however, calculation shows that temperatures sufficient to fuse the metals and the manganese silicate, or ferrous silicate produced, ought to be obtained.

THE THERMOCHEMISTRY OF HIGH TEMPERATURES.

The problem is: Knowing the heat evolved (or absorbed) in the formation of a compound, or in a double reaction, starting with the reacting materials cold, and ending with the products cold, what is the heat evolved (or absorbed) in either of the following cases?

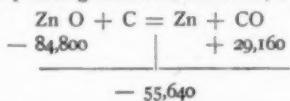
(a) Starting with the reagents cold and ending with the products hot.

(b) Starting with the reagents hot and ending with the products hot.

(c) Starting with the reagents hot and ending with the products cold.

Of these three cases (b) is the most general form of the problem, and occurs frequently in metallurgical practice, particularly in electrometallurgy; (a) is a more limited form, and requires less data for its calculation, while it is very frequently the desideratum in discussing the thermochemistry or heat requirements of a metallurgical process; (c) is derivable at once if the data exist for calculating (b), and is of such rare occurrence in practice that we can dispense with its lengthy discussion.

The thermochemical data already given and described in preceding sections enable us to calculate the heat of any chemical reaction starting with cold reagents and ending with the products cold. For instance: $(Zn, O) = 84,800$ Calories means that if we take 65 kilograms of solid zinc, at room temperature, and 16 kilograms of oxygen, as gas at room temperature, ignite them, and after the reaction cool the 81 kilograms of zinc oxide formed down to the same starting temperature, there will be developed a total of 84,800 Calories. Similarly, using the datum $(C, O) = 29,160$ Calories, we can construct and interpret the reduction reaction, starting with cold materials and finally ending with cold materials, as follows:



This reaction, as interpreted, stands for none of the above cases (a), (b) or (c); in fact, it represents only a calorimetric determination in the laboratory, and does not correspond to either of the three cases actually taking place in practice, that is, it is not directly applicable to practical conditions, without being modified by the conditions actually arising in practice.

Case (a): If we, in practice, start with the reagents cold, and the products pass away from the furnace hot, at some determined temperature t , the total heat energy necessary to cause this transformation is calculable in two ways. The first way is to follow the course of the reaction, and to say that the total heat absorbed is that necessary to heat the reacting bodies to the temperature t , plus the heat of the chemical reaction assumed as starting and finishing at that temperature.

The first of these items can be obtained if we know the sensible heat in the reacting bodies up to the temperature t ; it is a question of specific heats of the reacting bodies up to t (including any physical changes of state occurring in them between 0 and t); the second item requires a knowledge of the heat of formation of all the compounds involved, starting with their ingredients at t , and ending with the products at t . But the latter item is the general question of the heat of a reaction starting with the ingredients hot and ending with the products hot; it is the most general case, which we have designated as *Case (b)*, and which will be discussed later. This way of solving *Case (a)*, therefore, really includes the solution of *Case (b)*, and we will defer its consideration for the present. The second method of solving *Case (a)*, and one which does not involve the more general solution, is to take the heat of the reaction, starting with the ingredients cold and ending with the products cold—the ordinary heat of the reaction from ordinary thermochemical data—and to add to this the amount of heat which would be required to raise the products from zero to the temperature t . This, of course, does not actually represent the sequence in which the reactions take place in practice, but it accurately represents the heat involved or evolved in passing from the cold reagents to the hot products, and is, therefore, exactly the practical quantity which we are endeavoring to find. Moreover, it involves a knowledge of only the specific heats of the products, and not that of the ingredients or substances reacting.

Illustration: Starting with a mixture of zinc oxide and carbon in the proportions ZnO and C , at ordinary temperature, and shoveling them cold into a retort, how much heat is absorbed in converting them into Zn vapor and CO gas, issuing from the retort at $1300^\circ C$?

If we start to calculate this quantity, by first finding the heat necessary to heat ZnO and C up to 1300° , that is obtained by multiplying the weights of each by their mean specific heats from 0° to 1300° , and then by 1300 , as follows:

$$\begin{array}{l} \text{Calories.} \\ 81 \text{ kilos. } ZnO \times^* [0.1212 (1300) + 0.0000315 (1300)^2] = 17,075 \\ 12 \text{ " } C \times^* [0.5 (1300) - 120] = 7,800 \\ \hline \text{Sum} = 24,875 \end{array}$$

To this must then be added the heat of the reaction $ZnO + C = Zn + CO$, starting with the reacting bodies at 1300° , and ending with the products at the same temperature. This can only be found by solving the general *Case (b)* for this particular reaction, which we will find involves a knowledge of the heat required to raise Zn , O , C , ZnO and CO from 0° to t . Anticipating such a solution, we may say that the heat of the reaction starting and ending at 1300° is $- 75,216$ Calories, making the sum total of energy required $100,091$ Calories.

The solution is usually much simpler if we take the second method, and add to the heat of the reaction, starting and ending at zero ($- 55,640$ Calories), the heat required to raise 65 kilos. of zinc and 28 kilos. (22.22 cubic meters) of carbonous oxide, from their ordinary condition at zero to their normal condition at 1300° . The calculation for the CO gas is simply:

$$22.22 \times [0.303 (1300) + 0.000027 (1300)^2] = 9,766 \text{ Calories}$$

For the zinc, the calculation is more complicated:

Heat in solid zinc to the melting point (420°):

$$65 \times [0.0958 (420) + 0.000044 (420)^2] = 3,077 \text{ "}$$

Latent heat of fusion $65 \times 26.61 = 1,470 \text{ "}$

Heat in melted zinc, 420° to boiling point (930°):

$$65 \times [0.0958 + 0.000088 (420)] \times (930 - 420) = 4,228 \text{ "}$$

Latent heat of vaporization (Trouton's rule)

$$20 \times (930 + 273) = 24,060 \text{ "}$$

* Heat in 1 kilo of carbon, for temperatures above $1,000^\circ$, $0.5 t - 120$ (deduction from Weber's results); zinc oxide $0.1212 t + 0.0000315 t^2$ (determination by the author).

$$\text{Heat in zinc vapor (monatomic) } 5 \times \\ (1300 - 930) = \underline{1,850} \text{ Calories}$$

The total sensible heat required is, therefore, $9,766 + 34,685 = 44,451$ Calories, which, added to the 55,640 absorbed in the chemical reaction, if it started and ended at zero, makes a total heat requirement of 100,091 Calories for the practical carrying out of this reaction, starting with the reagents cold and ending with the hot products at 130° .

[To be absolutely accurate, regard should be paid in the above case to the fact that the above calculations are based on the substances being all at atmospheric pressure, while in the mixture of Zn vapor and CO gas each is under only 0.5 atmosphere tension. Since each of these represents a molecular weight, the outer work which has been included in the calculations is $2 \times zT = 2 \times 2 (1300 + 273) = 6292$ Calories, whereas it should really be only half that much, or 3146 Calories. The corrected heat required is, therefore, $100,091 - 3,146 = 96,945$ Calories, or 1,464 Calories per kilogram of zinc. This datum is exactly the net heat requirement on which calculations of the net electrical energy required to produce zinc from its oxide, or calculations of the net efficiency of an ordinary zinc furnace, would be based.]

Case (b): To calculate the heat of a chemical reaction starting and finishing at any temperature t , two methods are available: The most general solution, and that easiest to understand, is to calculate for each compound involved the heat of its formation at the temperature t , that is, the heat evolved if the elements start at t and the product is cooled to t . Having these heats of formation at t , they are used in the equation in just the same manner as the heats of formation at zero are ordinarily used in obtaining the heat of the reaction starting and ending at zero. The calculations are based on this general principle: The heat evolved when the cold elements unite to form the hot product at temperature t equals the heat of union at zero, minus the heat necessary to raise the product from zero to t ; if to this difference we add the heat which would be necessary to heat the uncombined elements from zero to t , the sum is the desired heat of formation at t .

Illustration: The heat of formation of ZnO at zero is 84,800, starting with cold Zn and O and ending with cold ZnO. If we started with cold Zn and O and ended with hot ZnO, say at 1,300°, the heat evolved altogether would be less than 84,800 by the sensible heat in the 81 kilograms of ZnO at 1,300°, which has already been calculated (see previous illustration) to be 17,075 Calories. The difference is 67,725 Calories, and represents the transformation from cold Zn and O to hot ZnO. If the Zn and O were heated to 1,300° before combining, they would contain as sensible heat the following quantities:

Heat in 65 kilograms of Zn (0 to 1300°)	
already calculated	34.685 Calories
Heat in 16 kilograms of O = 11.11 m ³ ×	
[0.303 (1300) + 0.000027 (1300) ²] = 4.884	"
Sum	39.569 "

And the heat evolved in passing from the hot reagents to the hot product at 1300° must be 67,725 plus this sensible heat, or 107,294 Calories. We can express this datum as follows: $(Zn, O)^{1300} = 107,294$, which means that when the zinc and oxygen taken in their normal state at 1300° combine to form ZnO at 1300° , 107,294 Calories are evolved.

A similar calculation for CO is as follows:

(C, O) = 29,160 Calories
Sensible heat in CO (0 to 1300°) already
calculated = 9,766 " "

Heat evolved when cold C and O form CO
at $1300^{\circ} = 10,304$

$$\text{Sensible heat in C (0 to } 1300^{\circ}) = 7800 \\ \text{ " " " O (" ") = 4884 } \quad 12,684 \text{ Calories}$$

Heat evolved hot C and O to hot CO = Sum = 32,078 " "
Or (C, O)¹⁸⁹⁰ = 32,078 "

Uniting the two data found, for the heats of formation of ZnO and CO at 1300° , in the equation of reduction, we have

$$\text{at } 1300^\circ = \begin{array}{c} \text{ZnO} + \text{C} = \text{Zn} + \text{CO} \\ -107,294 \quad \mid \quad +32,078 \\ \hline -75,216 \end{array}$$

The actual reduction is thus seen to absorb 19,576 Calories more at 1300° than at zero, an increase of over 35 per cent.

If to this heat of reaction at 1300° we add the heat necessary to raise the ZnO and C to 1300° (already calculated under Case (a) as 24,875 Calories), we will have a total heat requirement of 100,091 Calories, which would be required practically if we started with cold ZnO and C and ended with the hot Zn and CO. This agrees, as it indeed must, with the sum of the heat absorbed in the reaction at zero, 55,640, increased by the sensible heat in Zn and CO at 1300° , already found to be 44,457, or a total of 100,091.

Another method of calculating the heat of the reaction $\text{ZnO} + \text{C} = \text{Zn} + \text{CO}$ at 1300° , without using the heat of formation of ZnO and CO at 1300° , is based on the following general principle: If from the heat of any reaction, starting and ending cold, there be subtracted the heat necessary to raise the products from o to t, the difference is the heat of the transformation from cold reagents to hot products; if to this be added the heat which would be contained in the reagents if they were heated to t, the sum is the heat of transformation from heated reagents to heated products, all at the temperature t.

Illustration: The heat of the reaction we have been studying, starting and ending cold, is — 55.640 Calories

Sensible heat in Zn at 1300°	= 34,685		
" " CO "	= 9,766	44,451	"
	—		
Difference — 100,091			"
Sensible heat in ZnO at 1300°	= 17,075		"
" " C "	= 7,800	24,875	"
	—		
Sum — 75,216			"

The above is the simplest way of calculating the heat of any chemical reaction at any desired temperature, since it involves the knowledge of the heat capacities of only those substances which occur individually in the reaction, and not that of the elements of which the compounds present are composed. The above calculation, for instance, involves the heat capacities of ZnO , C , Zn and CO , but not that of oxygen, which does not occur free in the reaction.

Case (c): This hardly needs discussion, because if we have the data for calculating *Case (b)*, this case can be easily worked. If to the heat of the reaction at t° we add the heat given out by the products in cooling from t to 0, the sum is the total heat evolved in passing from the hot reagents to the cold products. This solution of the problem presupposes, however, the solution of *Case (b)*, and requires the maximum amount of data, but it has the advantage of following and representing the logical course of the reaction. A simpler solution is to add to the heat of the cold reaction at zero, the heat necessary to heat the ingredients to t , and the sum will be the quantity required.

Illustration: Taking the same case as before:

Heat of reaction at 1300°	=	75.216
Sensible heat in products at 1,300°	=	44.451
		Sum =
		30.765
or, Sensible heat in reagents at 1300°	=	24.875

Heat of reaction at zero	$= -55,640$	$4H^{\circ}O = 4(22.22) \times [0.34(960) + 0.00015(960)^3] = 41,300$	$69,860$ Calories
Sum $= -30,765$			

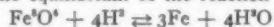
The reasoning involved in the above is simply that, starting with the reagents hot and ending with the products cold, the heat evolution must be the same whether we suppose the system to pass along the one path or the other.

GENERAL REMARKS.

It will be evident from this enunciation of principles and the illustrations adduced, that for many practical purposes the calculation according to *Case (a)* will suffice for finding the net energy involved in many metallurgical operations; it gives the sum total of energy necessary to be supplied to pass from the cold reagents to the hot products as they come from the furnace, but the two items of which this sum is composed do not actually represent the two items of the division of this total in the furnace, i. e., into heat necessary to heat the reagents to the reacting temperature and heat actually absorbed as the reaction takes place. The latter item can only be calculated by one of the two methods explained under *Case (b)*, and then the former item can be obtained by difference, or by direct use of the heat capacities of the reacting substances.

It is, of course, obvious that this whole subject of calculating the thermochemistry of high temperatures (as distinguished from the ordinary *zero thermochemistry*) necessitates the use of all available data regarding specific heats in the solid, liquid and gaseous states of both elements and compounds, and also in many cases of their latent heats of fusion and vaporization. When, however, the necessary physical data are known, or can be assumed with approximate accuracy, the way is open to make many calculations of the greatest value in practical metallurgy and chemistry. The exact heats of formation of chemical compounds at a certain temperature, which may be, and often are, very different from these values at zero, and having frequently different relations to each other, will explain in many cases many hitherto little understood and apparently contradictory reactions. The calculations also enable us to understand many reactions taking place only at high temperatures, to calculate whether they are really exothermic or endothermic at the temperatures at which they occur, and to compare these data with the data as to the heat of such reactions obtained by studying the chemical equilibrium of such reactions and deducing the heat of the reaction from the rate of displacement of the chemical equilibrium. One such example may suffice to suggest the large field here open to the scientific metallurgist.

Example: G. Preuner (*Zeitschrift für Physikalische Chemie*, March 15, 1904, p. 385) reports a long and careful investigation of the equilibrium of the reaction



in which he finds the equilibrium constant for different temperatures, and calculates from its value at 960° , by the use of Van't Hoff's formula, that the heat value of the reduction at that temperature is $-11,900$ Calories, and noticing the great difference between this value and the value derived from the ordinary heats of formation ($-270,800 + 4(58,060) = -38,560$), he concludes that the Van't Hoff formula gives wrong results when applied to this class of reactions. Now, the facts are that Preuner's observations were good, Van't Hoff's formula is correct, and applies, but the thermochemical value of the reaction, $-38,560$ Calories is the correct value only for the reaction beginning and ending at ordinary temperature. Our thermochemical principles enable us to calculate the heat of the reaction at 960° , as follows:

Heat of the reaction beginning and ending at zero $= -38,560$ Calories

Heat in products at 960° :

$$3Fe = 3(56) \times [0.218(960) - 39] Pionchon = 28,560$$

$4H^{\circ}O = 4(22.22) \times [0.34(960) + 0.00015(960)^3] = 41,300$	$69,860$ Calories
$Fe^{+}O^{+} = 232 \times [0.1447(960) + 0.0001878(960)^3] = 72,384$	
$4H^{+} = 4(22.22) \times [0.303(960) + 0.000027(960)^3] = 28,075$	$100,459$ "

The heat of the reaction at 960° is, therefore, according to our method of *Case (b)*, $-38,560 - 69,860 + 100,459 = 7,961$ Calories. It thus appears that Preuner's dilemma was mostly caused by his thinking that the thermochemical value of the reaction at zero should be a constant for any temperature; a proper thermochemical calculation removes the dilemma.

Since the whole treatment of the subject of the thermochemistry of high temperatures requires a knowledge of data concerning the heat capacity of elements and compounds in the solid, liquid and gaseous states, as well as of their latent heats of fusion and vaporization, the next instalment of these calculations will supply these data as far as they are known, and discuss a number of applications of these principles to various metallurgical processes.

Gold Extraction by Cyanide.

Before a meeting of the Scottish Section of the Society of Chemical Industry, held at Glasgow, on March 7, Mr. JOHN S. MACARTHUR, one of the inventors of the MacArthur-Forrest cyanide process, delivered a most interesting lecture on "Gold Extraction by Cyanide—a Retrospect." The paper is full of reminiscences concerning the early days of this process, which, during the last twenty years, has conquered the world. The full paper may be found in the issue of April 15, of the *Journal of the Society of Chemical Industry*.

The process was the outcome of extended systematic researches made by the MacArthur-Forrest Research Syndicate, to help the Cassel Gold Extracting Company in London out of their troubles. The problem was to find a proper solvent. Here, as always in commercial work with wet processes, the chief difficulty was to get pure solutions. In this special case, it meant to find a solvent which would dissolve gold, but not the base metals. This latter stipulation made a great many solvents of gold unsuitable for industrial work. "Naturally this excluded all reagents of the aqua regia and acid type. We could not hope to restrain an acid solution from a vigorous attack on the base metals, which, owing to their stronger affinity and greater mass, competed unfairly with the gold. In fact, the industry of molecular attack on gold had to be protected to prevent the indiscriminate dumping of base metals into the solution."

Potassium cyanide was first tried in November, 1886, but the result was apparently negative, since they always used sulphuretted hydrogen for precipitation of the gold, and, getting none, they assumed erroneously that no gold had been dissolved. Eleven months later this mistake was recognized and the development of the process followed.

Mr. MacArthur dealt in the lecture at some length on the question which was disputed for such a long time, whether air is required for the solution of the gold. Elsner claimed this. MacArthur's own experiments appeared to point the other way, since it was not known at that time that oxygen remains uncombined in aqueous solution along with the cyanide. MacLaurin established this fact, and to him is due the equation for the solution of gold.



Mr. MacArthur then discussed the question (still little understood although really fundamental), whether the reaction between cyanide and metallic gold is reproduced exactly in

* Approximate determination of heat in $Fe^{+}O^{+}$, made recently in author's laboratory, $Q = 0.1447t + 0.0001878t^3$.

the case of the gold contained in ores. "No allowance has been made for the number and variety of mineral substances, possibly unacted on themselves, but still capable of modifying the reaction between gold and cyanide. Highly suggestive work directed towards the elucidation of this complicated problem has been carried out by Gore, who found that metallic gold was dissolved more quickly when in contact with some minerals than with others, and that such inert substances as ground glass and sand had a distinctly accelerating influence. He found that a gold disc lying on clean white sand dissolved nearly five times as quickly as when merely immersed in cyanide solution. What is the nature of the action in this case, I do not pretend to say. No one has yet suggested that sand has any chemical action under the circumstances. Possibly they occlude oxygen—I cannot say. Another investigator found that the merest trace of ferric oxide induced the action. Again I do not pretend to explain; but, if this is so, the comparatively easy and rapid dissolving of gold from ores is accounted for, as practically all auriferous ores contain more or less ferric oxide."

The problem of getting the gold (and only the gold) into solution, was by far the most difficult part of the question. The precipitation of the gold from solution was comparatively easy. Mr. MacArthur favors, of course, precipitation by zinc shavings, although he says that "zinc precipitation is one of the weak points in the process; with care, the precipitation is complete to a few grains per ton, but the gold is collected in such fine mud, drying into dust, that loss is inevitable."

With electrolytic precipitation the trouble is that it gets more and more difficult to precipitate the gold out of the solution, the further the precipitation proceeds. "In practice there was always a comparatively high amount of gold left in the solution, which, though used over and over again on fresh lots of ore, led to loss by leakage and dissipation. In fact, it is a wonder to me, and a credit to the technical staff concerned, that good results were really obtained. The electric precipitation method is less used now than ever and seems to be dying out." This development is, according to the author, aided by the more extended introduction of the zinc-lead couple (by adding a small quantity of a lead salt to the gold-cyanide solution as it enters the zinc box).

Mr. MacArthur then gave some figures showing what the cyanide process has done for gold metallurgy. "One of the most beneficial effects of the cyanide process has been the introduction of exact methods, and working where rule of thumb had reigned supreme. Twenty years ago only a very few of the largest gold mines had their ores and tailings systematically assayed. Now, every gold mine of the slightest pretensions has its assay staff and equipment. In the old days the manager, who was miner, metallurgist and commercial head in one, knew how much gold he saved, but he did not know how much he lost; if he were a 'practical man' he rather feared to know this latter, and stoutly maintained that he recovered all the gold. All this is changed; cyanidation compelled the exact weighing, measuring and computing in its own department, and the cyanide department is generally the last. The exactitude had to begin at the beginning, hence a gold mining and reduction establishment is now conducted on lines that would do credit to a highly organized factory or even to a royal mint."

Mr. MacArthur finally made some suggestions as to possible improvements of the cyanide process. "The first point on which improvement is suggested is reduction in price of potassium cyanide. In the early days of the process (1892) we could buy potassium cyanide 98 per cent strong at 1s. 4d. per pound, now it is about 8d.; but as the consumption does not average one pound per ton of material treated, the saving of 8d. per ton is not of such importance as to materially affect the scope or economy of the process. In fact, if cyanide were as cheap as common salt, the economy on material presently worked would be measured only by pence per ton. I look for improvements in other directions."

"In ordinary cyanidation the extraction of gold probably does not average more than 80 per cent—any modification or improvements that would raise this average to 95 per cent would be much more valuable than a fall in the price of cyanide to the price of common salt. Assuming the average grade of tailings now treated to be 5 dwts. per ton, an additional recovery of 15 per cent would equal 3s. per ton, which is about the whole working cost of cyanidation. Thus, in my opinion, the betterment of the extraction is a most tempting field for research improvement."

"There is also improvement wanted in widening the field of operation in which cheap cyanide or a cheap process of cyanide recovery may play an important part. Ores containing a small amount of copper absorb so much cyanide that they cannot be commercially worked. This barrier still exists, though efforts with good promise of success to overcome or remove it have been made by several skilful workers. I anticipate that some day we shall be able to cyanide cupriferous gold ores—if so, the scope of the process will have been substantially enlarged."

"The cyanide process has seldom, if ever, been adopted for working purely silver ores, though it successfully treats many ores containing more silver than gold. Silver ores are even more complex and difficult to treat than gold ores, and, being more plentiful, a silver extraction process is urgently wanted, and doubtless some person, destined to succeed, is working out the problem now."

Mr. MacArthur refrained from speaking on his patents and restricted himself to a sympathetic quotation from Sir Isaac Newton: "If I get free of this present business I will resolutely bid adieu to it eternally, except what I do for my private satisfaction or leave to come out after me; for I see a man must either resolve to put out nothing new, or become a slave to defend it."

Vanadium and Titanium.

BY HANS GOLDSCHMIDT, PH.D.
(Concluded from page 170.)

TITANIUM.

With respect to titanium it may first be pointed out that it is useful as an addition to steel as well as especially to cast iron. The addition of titanium to cast iron by means of the aluminothermic reaction has already been discussed in this journal (Vol. I. p. 533, and Vol. II, p. 405). To describe this application briefly, a box filled with an aluminothermic mixture, which gives off ferrotitanium, is introduced into the cast iron. This box is fixed on an iron rod and brought into the bath so that the reaction of the mixture occurs on the bottom of the crucible.

This produces an effect in two respects: firstly, titanium is alloyed with the cast iron; secondly, and this is of special importance, the whole content of the crucible is most thoroughly stirred and mixed while the reaction goes on (its duration being about a minute); the result is that all impurities, particles of slag, etc., are brought to the surface. At the same time the chemical composition of the iron is changed, not only by the introduction of small quantities of titanium, but by the thorough refining of the bath, due to the mechanical stirring.

It is remarkable that even very low percentages of titanium (below 0.1 per cent) may produce remarkable changes, if introduced into cast iron by the so-called box reaction. A large works in the Rhenish-Westphalian industrial district has recently made experiments in great detail on the action of titanium on cast iron. Table I gives the results with respect to bending strength and tensile strength for a certain kind of cast iron treated with thermit, the analysis being also given in the table. The figures are averages of several determinations. The tests were made with rods of four different dimensions;

in the case of bending strength the load being applied in the center. I is a rod, 1000 mm. long, between the two points near the terminals on which it rests; the cross-section is square, 30×30 mm. Rods II, III, IV have a circular cross-section; II, diameter 40 mm., length 800 mm.; III, diameter 30 mm., length 600 mm.; IV, length 200 mm. *a* always refers to cast iron without titanium thermit, *b* to cast iron treated with titanium thermit. Although the table shows that in this case the strength of the iron has been increased more or less by means of the "box reaction," yet these figures alone do not give an exact idea of the useful application of titanium, since, as well known, a greater strength of the iron may also be produced easily by other means.

TABLE I.

Rod I.	Rod II.	Rod III.	Rod IV.
Bending Strength in Kg.			
<i>a</i> 22.12	<i>b</i> 22.48	<i>a</i> 22.83	<i>b</i> 27.62
26.54	26.80	27.69	30.39
Tensile Strength in Kg.			
<i>a</i> 12.64	<i>b</i> 13.39	<i>a</i> 12.59	<i>b</i> 14.57
14.37	15.19	15.29	15.9
Analysis.			
<i>a</i> 0.766 Mn, 0.541 P, 3.030 Si, 0.153 S, 3.513 C, 2.805 graphite.			
<i>b</i> 0.698 Mn, 0.534 P, 2.962 Si, 0.142 S, 3.515 C, 2.738 graphite.			

The comparative analysis in Table I does not show very much, although it is evident that the content of manganese and sulphur has decreased in the iron treated with titanium. In general, however, the content of sulphur is even more changed by the "box reaction" than is shown by Table I.

It is somewhat surprising that in spite of the difference in the strength of the material the analyses show very small differences in the composition. This is due to the fact that the chemical analysis, as carried out at present with our ordinary means, do not show sufficiently the quality of iron and steel. For, above all, dissolved oxides or gases can be determined only with great difficulty by chemical analysis. As far as such analyses are possible at all, their great difficulty prevents them from being used in the ordinary course of a steel analysis. I will call attention specially to the impossibility of determining dissolved oxygen compounds of chromium and manganese—oxides which cannot be reduced by hydrogen—when metallic chromium and manganese are simultaneously present. It is just such dissolved oxides which play an important part in steels. By the "box reaction" and by the simultaneous introduction of small quantities of titanium, the iron is freed from impurities, like gases and oxides, the latter being reduced. This explains why in this case chemical analysis does not show the improvement of the material; the improvement manifests itself in mechanical respect, *i. e.*, the cast iron gets a denser

structure, the formation of pores is avoided and the tensile strength and bending strength increase.

By means of the aluminothermic reaction a certain quantity of heat is produced in the cast iron, but it is comparatively small, when calculated in calories. Nevertheless, a much greater fluidity is imparted to the cast iron. The mechanical stirring effect is undoubtedly a special factor. Now, since the fluidity of the iron is increased, it is possible to cast it at a lower temperature. Every practical engineer knows what this means in the case of complicated castings. Moreover, in this case piping is much less than in iron cast at a higher temperature, and it is thus much easier to avoid the undesirable pipe holes in the casting. Titanium has an important effect on the density of the casting, since the formation of pores is entirely avoided by proper care.

It is unnecessary to say that the treatment of cast iron with titanium is not a universal remedy to prevent all and any undesirable surprise with the completed casting during testing and machining. It is impossible to give a prescription which fits all cases. In the introduction of titanium thermit into foundries it has been found that every foundry must acquire its own experience, especially on the question for which castings the use of titanium thermit is advisable, and for which the expense, although low, is unnecessary.

So much about the application of titanium in cast iron. More recently titanium is introduced into steel in form of a 20 per cent ferro-titanium alloy, free from carbon. After it had been placed on the market it took some time until this product became popular; but since about two years it is regularly used by a number of steel works. It is applied in a quantity which I had already proposed at an earlier date on the basis of some experiments, namely, about $\frac{1}{2}$ to 1 per cent. Experiments, with up to 6 per cent titanium, have so far failed to give good results.

An addition of titanium to steel, which contains about 0.8 to 1.2 per cent of carbon, scarcely increases the hardness of the steel, but it raises its elasticity, and is, therefore, advantageous for steels which are subjected to much percussion, and which it is important to render as little brittle as possible. It is also used for cutting tool steels.

It is remarkable that an addition of titanium to steel increases its toughness, and there are a number of steel manufacturers who would add small quantities of titanium to any steel, in order to produce a denser structure and to combine nitrogen. Such a varied application of titanium, however, has not yet been introduced into practice. This is another indication of the difficulty of introducing a new element with sure success into commercial work; and with this remark I am led back to what I said in the introduction.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

BY GEORGE P. SCHOLL, PH. D.

ELECTRIC FURNACES AND FURNACE PRODUCTS.

Material for Furnace Linings.—H. G. Turner, London, England. Patent 785,841, March 28, 1905. Application filed April 24, 1903.

The material is prepared by heating magnesite in an electric furnace at the temperature of the electric arc to a point at which the material crystallizes. The product is either allowed to cool or may be rapidly cooled by being poured or thrown into water or another liquid. The product is stated to be of a crystalline character, and black, grayish or greenish color, and has a specific gravity of 3.58. It is ground and mixed with a suitable binder, such as a solution of magnesium chloride, water glass, boric acid, borax, etc. It is then made into a paste

with water and applied as a coating to the furnace lining, or pressed into bricks or plates, which are afterwards baked.

Electrode for Electric Furnaces.—E. F. Price, G. E. Cox and J. G. Marshall, Niagara Falls, Assignors to Union Carbide Co. Patent 785,832, March 28, 1905. Application filed Oct. 19, 1903.

The invention relates more particularly to electrodes used in calcium carbide furnaces. On account of their high conductivity, uniform composition and durability, artificial graphite rods have been found desirable for this purpose, but they suffer from the disadvantage of unduly transmitting heat from the zone of reaction upwards to the metallic holder. The electrode constructed by the inventors is intended to overcome this dis-

advantage. For this purpose the electrode holder is provided with a water chamber, and each of the graphite rods is screwed into a metallic socket and projects into the water chamber, so as to allow an intermediate space for the circulation of water. These water-cooled holders, moreover, are preferably introduced into the water-cooled cast-iron top plate of a hood, such as is used in the Horry carbide furnace. The high specific conductivity of graphite as compared with carbon allows the use of much thinner rods of the former material, but they are mechanically weak and will break if merely substituted for the carbon electrodes of a carbide furnace. Furthermore, these thin graphite rods are readily oxidized by the atmosphere, owing to the high temperature to which they are raised. It is, therefore, necessary to reinforce and strengthen them, and this is preferably done by a filling, of cement of high resistance, placed between and around the rods. The cement may consist of ordinary asbestos or furnace-cement, mixed with ground bituminous coal and siloxicon. To strengthen the body of cement and protect it from scaling off when heated, a support of thin "expanded iron" is wrapped around the rods and plastered over with the cement. It is also sometimes desirable to protect one or more of the front rods of each electrode, which are more exposed to air, by coating them with tar and pushing them into a closely fitting iron sleeve, the upper end of which is screwed into the electrode holder. It is stated that this invention makes it possible to use graphite electrodes in a carbide furnace, the greater cost of the graphite being offset by the reduction in the thickness and the length of the electrode rods.

ELECTROLYTIC PRODUCTION OF METALS AND COMPOUNDS.

Process of Electrodepositing Metals.—E. D. Kendall, Brooklyn. Patent 786,221, March 28, 1905. Application filed Oct. 28, 1903.

The process relates particularly to the deposition of zinc on iron and steel, the so-called cold galvanizing. It depends essentially upon the use of zinc sulphoglycerate as electrolyte. The electrolyte is prepared by first acting on anhydrous or nearly anhydrous glycerol with strong sulphuric acid, with or without the application of heat, in order to form sulphoglyceric acid. This product is then diluted with a limited quantity of water and then saturated with zinc, preferably by agitating it with an excess of zinc oxide or zinc hydroxide, and finally more water is added so as to form a comparatively dilute solution of zinc sulphoglycerate, which is used as electrolyte. If a somewhat concentrated solution of zinc sulphoglycerate is used as electrolyte, the liquid is stated to have a high conductivity, and a current having an e. m. f. of even less than 1 volt, when a zinc anode is used, will suffice for a rapid deposition of zinc. With a more dilute solution an e. m. f. of 2 or 3 volts is preferably used, unless the conductivity of the electrolyte be increased by the addition of a suitable salt, such as sodium sulphate. With a properly adjusted current, the density of which is not disclosed, the pure zinc deposited on polished cathode surfaces is stated to have remarkable smoothness and uniformity. Electrolysis is facilitated by heating the electrolyte, but when it is used at ordinary temperature the rate of deposition and the character of the deposited zinc is stated to be satisfactory, while the operation requires less supervision.

Deposition Tank.—T. E. Lewis and J. A. Corey, London, England. Patent 786,978, April 11, 1905. Application filed Feb. 23, 1904.

The invention relates to the electrodeposition of metals and particularly to the production of printers' electrotypes. The apparatus comprises a circular vat, upon which is mounted an annular cathode, which can be rotated by suitable mechanical means. The moulds to be electrotyped are suspended from this cathode ring. The anodes are supported upon a metallic ring, carried by a spider, which is fastened upon a spindle centrally located within the vat. The cathode was made rotating for the purpose of using high-current densities, made possible by this

means, so as to effect a uniform and regaline metallic deposit and to carry on the electrodeposition rapidly.

Electrolytic Method.—A. S. Ramage, Detroit. Patent 782,221, April 11, 1905. Application filed Jan. 31, 1905.

The method provides for the electrolysis of a metallic salt in aqueous solution in a suitable cell, which is usually divided into a positive and a negative compartment. According to the nature of the electrolyte, a metallic hydroxide or a metal is produced at the cathode, while at the anode a secondary product, the so-called aniline black, is produced by the oxidation of an aniline salt, preferably the sulphate or hydrochloride of aniline. As electrolytes either the sulphate or the chloride of sodium may be used, preferably in a cell of the mercury cathode or the gravity type. In either case sodium is deposited at the cathode and converted into hydroxide in the usual manner. In electrolyzing sodium sulphate anodes of lead are preferably used, no oxygen being evolved at the anode, but converting the aniline sulphate $(C_6H_5N)_2H_2SO_4$, into aniline black. If sodium chloride is electrolyzed with graphite anodes in the presence of aniline hydrochloride ($C_6H_5N \cdot HCl$) aniline black is formed. The oxidation in this case is stated to be presumably due to the decomposition of water by chlorine in presence of the aniline salt, according to the equation, $Cl_2 + H_2O = 2HCl + O$. If ferrous sulphate be electrolyzed in presence of aniline sulphate, aniline black is formed, while metallic iron is deposited on the cathode. The anode liquor containing the sulphuric or hydrochloric acid, as the case may be, is formed during the electrolysis, and the aniline black in suspension is withdrawn from the cell, preferably continuously, the aniline black is separated by filtration or otherwise, and the acid liquid utilized for the production of additional quantities of the aniline salt.

Manufacture of Carbon Tetrafluoride Gas.—J. A. Lyons and E. C. Broadwell, Chicago. Patent 785,961, March 28, 1905. Application filed Sept. 16, 1903.

The process is carried out by fusing in a metallic crucible a mixture of sodium and potassium fluoride, although the fluorides of any of the alkaline earth or earth metals may be used, among which CaF_2 is suitable and practicable. The crucible serves as cathode and is covered by a non-conducting lid, through an opening in which is slipped a non-conducting tubular vessel with an open-work bottom, a feed opening in its upper part and a gas escape pipe. Into this vessel is introduced a graphite rod, reaching to its bottom and connected with the anode. Around its lower end is placed a quantity of charcoal, lampblack or other suitable carbonaceous material, which floats upon the surface of the bath. A cylindrical partition, open at the bottom, prevents the products formed in the anodic tube from passing towards the cathode. When the melt is electrolyzed, the metal is set free upon the cathode, while fluorine gas is liberated at the anode, where it combines with the carbonaceous material surrounding the anode rod, with the production of carbon tetrafluoride gas. The reaction is stated to take place at a temperature of approximately $1000^{\circ} C.$ The carbonaceous material surrounding the anode is stated to protect the comparatively costly anode from unnecessary waste.

Production of Boron by Electrolysis.—J. A. Lyons and E. C. Broadwell, Chicago. Patent 785,962, March 28, 1905. Application filed Sept. 16, 1903.

The invention aims at the production of boron in conjunction with highly electropositive metals, such as potassium, sodium, manganese, chromium, molybdenum, tungsten, uranium and vanadium. For this purpose the borates of these metals, either basic or neutral, are electrolyzed at a temperature of $1100^{\circ} C.$, in a tapered iron vessel, which acts as the negative electrode. A carbon rod is used as the positive electrode, which is placed into a cylinder of graphite, open at the bottom, and suitably insulated, which acts as a partition, and thus serves to keep the products obtained at the anode and cathode separate. During electrolysis the borates are tested to

be decomposed in such a manner that the metal is set free upon the inner surface of the containing vessel, while the hypothetical ion, or radical B_4O_7 or B_2O_4 , is deposited at the positive electrode. The carbon of the latter, being kept at an incandescent heat by the current on account of its relatively small area, is said to reduce the B_2O_3 or B_4O_7 to boron, carbon monoxide gas being set free. By surrounding the carbon anode with different metals their borides are claimed to be obtained.

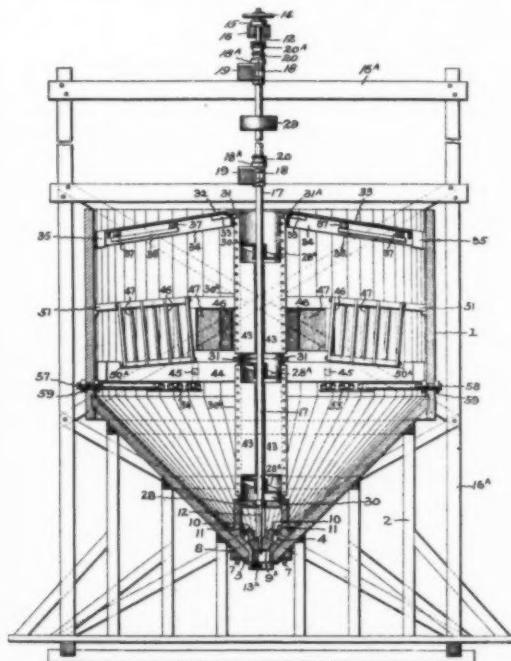
Method of Extracting Metals from Ore by Electricity.—E. L. Priest, Oakland, Cal. Patent 784,885, March 14, 1905. Application filed April 5, 1904.

The inventor first proposes again the well-known expedient of bringing the ores to be treated into suitable form, by finely grinding them and mixing them with carbon and a binding material, so that the resulting material may be used as electrodes. He also illustrates a tank, filled with a liquid of any suitable character, such as acidulated or salted water. At one side of the tank, quite close to its side, a zinc plate is introduced in a vertical position, which is connected with one terminal of the current. Above the middle of the tank, just touching the water, is an electrode prepared as above described. The process is explained by him as follows: "Where the prepared ore masses touch the water the current is completed through them, and as the arc is established the conductor is consumed, while the ore is reduced and drops into the water. The carbon conductors serve also to heat the ore. These ore masses, with their consumable conductors, may be prepared in any suitable manner, sizes and numbers, and a plurality of them may be connected in multiple arc. By such initial preparation of the ore, the electric current is completed

The apparatus is intended for the treatment of pulverized ore, in the form of a pulp consisting of ore and chemical solutions. It is illustrated in vertical cross-section in Fig. 1, and consists of a stationary tank 1, of a straight cylindrical form in its upper part, while provided with a sloping bottom. A discharge opening 3 is located in the axial center of the conical bottom, which is closed by a valve 9^a, which can be lifted by means of a hand-wheel 14 on top of the apparatus, fastened to the valve stem 12. A number of screw propellers 28^a are also placed on the shaft, the latter being revolved by means of a belt on the pulley 29. Upon the top of the valve casing is secured the lower end of a cylindrical casing 30, the interior of which communicates with the tank by openings in the valve cage. A device 32, called the deflector, serves to distribute the ore pulp. The anodes 46 consist of carbon plates suitably secured in frames, while the cathodes are lead plates. Each cathode can be easily lifted out. As some ores are treated with advantage by heating the pulp, provision is made for heating coils 54 and 55. The operation of the apparatus is as follows: Pulp, to which solution has been added so as to bring it to the desired consistency, is run into the tank until the latter is about full. Power is then applied to the shaft and the propellers are rotated rapidly, which has the effect of lifting the ore pulp bodily in the central casing. The pulp overflows over the top of the deflector in contact with the atmosphere and is thus aerated. As it drops from the edge of the deflector it falls into the tank and flows into direct contact with the anode and cathode plates, along which it descends in a gentle stream. It passes then into the central casing again, and is in turn elevated again and the whole solution is thus continuously circulated and agitated. Each charge of pulp is treated for a certain length of time, according to circumstances, and usually varying between 2 and 12 hours, until tests show that a satisfactory extraction of the values have been obtained. The charge is run into receiving tanks, and the clarified solution returned and strengthened and used again with other charges in the tank. (See also our volume II, 286.)

Process of Producing Metals and Alloys.—H. C. Blackmore, Mount Vernon, N. Y. Patent 786,185, March 28, 1905. Application filed Nov. 15, 1904.

The invention relates particularly to the production of aluminium alloys from metal aluminates. The process is carried



out, as shown in vertical longitudinal cross-section in Fig. 1, consists of an iron box, *A*, lined with magnesia brick, *Z*. The latter also covers the carbon bottom, *B*, except in channels beneath the direct-current anodes, *G*, towards which the uncovered parts of the bottom act as cathodes. They also act as electrodes opposed to the alternating-current electrodes, *T*. In starting the process an alternating current is established between the electrodes, *G*, and the bottom, so as to produce arcs, in order to fuse the material of the charge as it is fed in, the electrodes, *G*, being withdrawn more and more from the bottom as the depth of the molten charge increases. When enough has been accumulated, the alternating-current contact with the electrode, *G*, is broken and transferred to the electrodes, *T*. The electrodes, *G*, are then connected with the direct current, and a metal aluminate, such as copper aluminate, is fed in. The alloy or metal accumulates in the channels, *Y*, and is withdrawn at *L*. Instead of aluminates there may be used chromates, vanadates, stannates, tungstates, molybdates, etc., the alloys of which are desired.

Process of Extracting Aluminium or Other Metals.—H. S. Blackmore, Mount Vernon, N. Y. Patent 786,244, March 28, 1905. Original application filed Sept. 12, 1903; divided and refiled Jan. 7, 1905.

The electrolyte proposed by the inventor consists of a mixture of aluminium oxide with aluminium fluoride, about one of the former to two of the latter by weight. The charge is fused in about the same manner as outlined above, namely, by means of an alternating current between electrodes different from those used for electrolytic purposes. When enough of the fused charge has accumulated, electrolysis is started, by means of a current passing between carbon anodes and the carbon lining of the electrolytic vessel. The tension of the current is given as 3 volts, and the current density as 85 amperes per square inch of anode surface exposed. The fluorine contents of the bath are said not to be attacked during electrolysis. The temperature is maintained at approximately 1800° F. The bath is replenished with aluminium oxide as required.

Electroplating Apparatus.—H. Fleischer and C. H. Fleischer, New Britain, Conn. Patent 784,617, March 14, 1905. Application filed May 23, 1904.

The apparatus comprises a rectangular tank which contains the plating solution. The anodes as well as the cathodes are moved mechanically through the solution by means of driving chains, one of them being placed at each longitudinal side of the tank. The cathode chains are placed a little below the anode chains. A series of rods connects the two anode and the two cathode chains respectively, the anodes being suspended from the former and the cathodes from the latter. The guide sprockets over which the cathode chains run are so arranged that the cathodes will be lowered alternately with the anodes into the solution. Each anode is lifted up over the edges of a small tank and immersed for a short time in a cleansing solution, with which this tank is filled. By causing the articles to be moved through the solution alternately with the anodes, each line of articles suspended from a cathode carrier is moving into a sphere of solution which has been enriched by the dissolution of the anode immediately in front of it, which anode practically recharges the solution, which has been partially depleted of its metallic contents by the cathode immediately preceding it. Various preparatory baths for the articles to be plated as well as washing tanks can, of course, be added, to be traversed by the movable chains and the anodes and articles suspended from them.

Process of Metallizing Fabrics.—C. Danilevsky and S. Tourchaninoff, St. Petersburg. Patent 785,541, March 21, 1905. Application filed July 20, 1901.

The process applies to the deposition of metal by electrolysis through the whole thickness of fabrics which are porous

and pervious to liquids, such as leather and its substitutes, asbestos, linen, wood, cotton, etc. It is carried out in an ordinary rectangular wooden vessel, provided with a series of rods placed across its top, from which are suspended alternately copper plates and frames containing the fabric to be metallized. The latter has been subjected to a preliminary boiling process in a suitable alkaline or acid liquid, and one of its faces has received a backing of a copper wire fabric or metal plate or other conducting layer. The bath for electroplating is either composed of citrate of copper, 10 to 20 grams, and boroglyceric acid, 2 to 6 grams, to 1 liter of water; nitrate of copper, 10 to 20 grams, and lactate of ammonium, 5 to 10 grams, to 1 liter of water, or borate of copper, 5 to 15 grams, and boroglyceric acid, 2 to 6 grams, to 1 liter of water. The backing consists preferably of thin wire gauze rubbed with graphite, so that it can easily be separated from the metallized fabric. The latter, after metallization, is washed and immersed in an aqueous solution of chloride of tin and cyanide of potassium, so as to cover the metallic particles with tin.

Plating Apparatus.—L. Schulte, New York. Patent 787,701, April 18, 1905. Application filed Sept. 17, 1904.

The apparatus is intended for plating all kinds of articles, especially sheet metal, band iron, wire and the like. It consists of a tank filled with the electrolyte, which contains two anode plates, between which passes a movable cathode carrier in electrical contact with contact members situated at the ends of the tank. The movable cathode carrier is preferably formed of a number of insulated endless cables, connected with each other by insulated transverse bars, provided with contact points. The insulated cables pass around rollers journaled in the sides of the tank at or near the ends. If it is desired to plate small articles the latter are placed in a metallic perforated tray or basket.

Method of Electrolytic Separation.—W. Hoopes, Pittsburg, Pa. Patent 788,315, April 25, 1905. Application filed Nov. 30, 1904.

The inventor claims to have discovered that such metals which cannot be readily separated from aqueous solutions of their salts can be readily obtained if these salts be dissolved in liquid anhydrous ammonia. The process is stated to be especially applicable to the production of magnesium by the electrolysis of a solution of magnesium chloride in anhydrous ammonia. The process requires a vessel in which the ammonia can be held in liquid condition. The apparatus shown in the specification consists of a glass vessel, set in an outer vessel filled with alcohol or other liquid of very low freezing point. It contains a coil of pipe, through which a refrigerating fluid, such as carbonic acid, ammonia, etc., circulates. This chills the alcohol, which in turn chills the liquid ammonia in the inner vessel, and prevents substantial loss by evaporation. The electrolytic vessel is divided by a porous partition into two compartments, one of which contains an anode of carbon, and the other a cathode of iron. Both compartments are filled with liquid anhydrous ammonia. Magnesium chloride is dissolved in the anode compartment, and anhydrous magnesium chloride, with or without a little sodium chloride, in the cathode compartment. Both solutions are preferably saturated, an excess of magnesium chloride being preferably added. Upon passing the current, magnesium is deposited at the cathode and chlorine liberated at the anode, a current of 5 volts with a current density of 0.1 amp. per square inch of anode surface having been found suitable. The inventor states that he has separated sodium, potassium, chromium, iron and silver by following methods similar to that described for magnesium. Thus, iron has been purified by immersing an iron cathode and an iron anode, containing silicon and carbon, in a solution of iron, cyanide and potassium cyanide in ammonia, pure iron being obtained on the cathode, carbon and silicon not being dissolved.

Process of Reducing Metals from their Solutions.—C. B. Jacobs, East Orange, N. J., assignor to the Ampere Electrochemical Co., Port Chester, N. Y. Patent 788,584, May 2, 1905. Application filed June 8, 1900.

The invention relates to the reduction of gold from its cyanide and chloride solutions by means of phosphide of hydrogen, and is an improvement upon a former patent granted to the inventor. He has now discovered that if the solutions containing the noble metals together with base metals be made acid before the treatment with phosphide of hydrogen, the base metals are entirely unaffected, and only the noble metal is acted upon. In case the silver is present with the gold the former is at once precipitated as silver chloride and filtered off. With cyanide of gold solutions the reaction is claimed to be, in the first place, $\text{KAuCy}_2 + \text{HCl} = \text{HAuCy}_2 + \text{KCl}$, thus leading to the formation of aurocyanic acid. When the latter is subjected to the action of hydrogen phosphide gas, the following reaction is stated to take place: $\text{HAuCy}_2\text{PH}_3 = \text{AuP} + 2\text{HCy} + \text{H}_2$, a phosphide of gold being precipitated, which, according to analysis, corresponds to the formula $\text{AuP}_4\text{H}_2\text{O}$. The hydrocyanic acid formed is stated to be reconverted into potassium cyanide by treatment with caustic potash solution. The precipitate is heated at a low heat, in order to drive off the phosphorus. The gaseous precipitant is produced by putting calcium phosphide into water and collecting the hydrogen phosphide resulting therefrom in a gasholder. The precipitating tank is lined with cloth or canvas of fine mesh, so as to collect the precipitate. As an example of the practical operation of the process it is stated that a cyanide mill solution corresponding to 1 ounce of gold per ton of solution was used, in which 10 ounces of copper and iron had been dissolved. The fine gold recovered was equal to .989 ounce, and no trace of iron or copper could be found in it. The consumption of raw materials was as follows: 6.24 pounds of calcium phosphide per ton of solution and 0.75 pound of hydrochloric acid for the same quantity; 1.5 pounds of caustic potash being used in the regeneration of potassium cyanide. An extremely dilute mill solution of 1 ounce of gold to 25 tons of solution gave a recovery of 96.5 per cent of the gold.

Manufacture of Chlorates and Perchlorates.—M. Couleru, Geneva, Switzerland. Patent 788,631, May 2, 1905. Application filed Nov. 12, 1904.

The process devised by the author depends essentially on the use of salts of certain metals, and especially the chlorides of lead, manganese, etc., in order to neutralize the alkali formed in the electrolysis of a chloride solution for the purpose of producing chlorate. The ensuing reaction is as follows: $2\text{KOH} + \text{PbCl}_2 = \text{Pb}(\text{OH})_2 + 2\text{KCl}$. As the liquid resulting from the electrolysis always contains more or less hypochlorites, the latter immediately transform the $\text{Pb}(\text{OH})_2$ into peroxide of lead, according to the formula $\text{Pb}(\text{OH})_2 + \text{KClO} = \text{PbO}_2 + \text{KCl} + \text{H}_2\text{O}$. The peroxide is heavy, can be easily separated from the liquor and forms a by-product of the process. The solution supplied to the electrolytic cell consists of a saturated solution of sodium or potassium chloride, with a small proportion of a chromate, such as chromate of sodium. The electrolyzed solution is transferred to another receptacle, and chloride of lead in solid form is added, preferably in the form of a very fine powder, and at a temperature of about 80°C , the action beginning at about 40° and continuing up to 90° or more, but being most effective at 80°C .

Plant for the Electrodeposition of Metals.—A. G. Betts, Troy, N. Y. Patent 789,353, May 9, 1905. Application filed April 11, 1904.

The invention relates to an arrangement of electrodes which permits the use of very large tanks, its object being to reduce either the size or the cost of an electrolytic metal depositing plant, or both; particularly of an electrolytic refinery. The depositing plant is more in the nature of a flooded floor, on which the operations are carried out, than the usual large number of individual tanks, the elimination of a large number

of tank sides and ends and the intervening spaces, varying in cost of construction and in space. The invention is stated to be of special advantage in an electrolytic lead refinery, as a metallic lining, which prevents leaks, is expensive, and other methods of making tight tanks require thick sides and bottoms. One arrangement of the electrodes is shown in Fig. 3. A tank 1 of any desired length, with the middle part removed, contains the electrolytic solution from which metal is deposited on the anodes 2 and cathodes 3. The current enters through

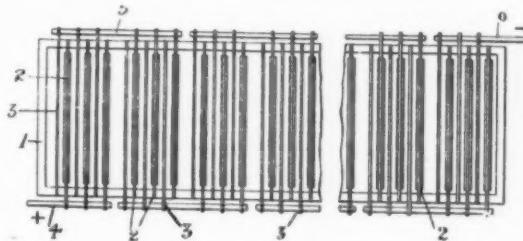


FIG. 3.—ELECTRODE ARRANGEMENT FOR ELECTROLYTIC PLANT.

the positive bus-bar 4, passes to the anodes connected to it, flows through the solution to the cathodes and thence to the conductor 5. From there it goes to the next series of anodes, and continues passing in that manner through the whole solution, until it leaves the tank by the negative bus-bar 6. It is stated that by leaving a double space between the anode of one block of electrodes in multiple and the cathode of the next block of electrodes in multiple, and so doubling the local resistance, there is obtained an equal flow of electric current from both sides of all electrodes, with the exception of an anode at one end and a cathode on the other.

Process of Electrolytically Refining Copper Alloys. A. G. Betts, Troy, N. Y. Patent 789,523, May 9, 1905. Application filed April 11, 1904.

The first step of the process consists in electrolytically dissolving the copper-nickel alloy, by using it as anode in an acid solution of sulphate of copper, copper being deposited on the cathode. The nickel dissolved from the anodes remains in solution as sulphate, and as the latter therefore increases constantly in nickel, some of it is occasionally withdrawn and replaced by fresh copper sulphate solution. The nickel sulphate solution is freed from copper by well-known electrolytic or chemical methods, and the pure solution is electrolyzed with an anode of spongy lead, such as is used in storage batteries. Nickel is deposited on the cathode, and the lead is partly converted into lead sulphate. A solution of sulphuric acid is electrolyzed, using the spongy lead electrode as cathode and a lead peroxide anode, which is partly converted into sulphate. As a result the solution becomes enriched in sulphuric acid, the lead sulphate of the spongy lead electrode being reconverted into spongy lead for further use in depositing nickel from the solution of its sulphate, and the lead sulphate of the lead peroxide electrode being converted into lead peroxide, as in charging a storage battery. If the lead peroxide electrode is used, after it is thoroughly peroxidized, it is brought into a solution containing sulphuric acid, in which is also suspended an electrode of copper or a nickel copper alloy or fragments, such as may be supported on a conductor. On closing the circuit, electric energy is generated, with the conversion of a part of the lead peroxide into lead sulphate and solution of the copper or copper-nickel anode. It is stated that the electric energy thus produced may be most easily utilized by placing the cell in the refining circuit, when it operates to raise the voltage of the current passing through instead of depressing the voltage, as in the case of most electrolytic tanks. The copper sulphate or nickel-copper sulphate solution produced goes to the electrolytic copper-depositing and copper-nickel dissolving tank. The process thus described is regenerative as

regards the sulphuric acid and partly as regards the electric energy used; a plain lead anode, or one of other insoluble material, may, however, be used.

Process of Producing Tartaric Acid and its Salts.—C. Ellis, Boston. Patent 789,269, May 9, 1905. Application filed Dec. 3, 1903.

The process aims at carrying out the electrolytic oxidation of saccharine matter up to the point where tartaric acid is formed and then converting the latter into an insoluble product. In the gradual oxidation by electrolysis of saccharine material various monobasic and dibasic acids are produced, such as gluconic, saccharine, tartaric, lactic, formic and carbonic. The relative quantity of these higher acids is, however, small in the electrolyte on account of this gradual oxidation. In the carrying out of this invention the electrolyte is a 10 per cent solution of grape sugar, made slightly alkaline by the addition of 1 per cent carbonate of potash. Electrolysis is carried out at a temperature of 10° C., the current strength being kept at about 2 amps (current density is not disclosed), while the electromotive force ought not to exceed 10 volts. The electrolyte is gently stirred, and gradually a crystalline deposit of acid potassium tartrate is said to form and to deposit. More alkali is added from time to time, in order to supply the necessary potash, and the electrolysis is continued as long as the tartrate continues to form. It is stated that from 2 to 10 per cent of tartaric acid may thus be obtained. Various salts, such as potassium sulphate, may be added to the electrolyte in order to increase its conductivity. Potassium acetate may be used in place of the potassium carbonate as a source of potash, for the formation of insoluble potassium hydrogen tartrate, in which case the reaction of the electrolyte may be kept acid. The tartaric acid compounds thus obtained may be purified from traces of saccharates by crystallization.

Apparatus for Electrolyzing Liquids.—L. Dion, New York. Patent 789,146, May 9, 1905. Application filed June 10, 1904.

The apparatus, claimed to be especially useful in the treatment of mine waters for the recovery of the metal dissolved therein, consists essentially of an electrolytic chamber, provided with electrodes formed of triangular-shaped bars or tubes. Several series of concentric rows of electrodes are provided, alternately positive and negative. The liquid, after being electrolyzed in this chamber, passes through two filtering chambers, which remove the metals, which are stated to have been separated by the action of the electric current in the electrolytic vessel.

STORAGE BATTERIES.

Gas Separator for Storage Batteries.—T. A. Edison, Orange, N. J. Assignor to Edison Storage Battery Co. Patent 785,297, March 21, 1905. Application filed Aug. 16, 1904.

The invention applies to an improved construction in Mr. Edison's storage battery, for the purpose of separating mechanically entrained globules of the electrolyte and to get over certain difficulties apparent in his previous construction, described in ELECTROCHEMICAL INDUSTRY, Vol. III., p. 000. The valve is made of glass, with a hollow spherical head and a projection for centering it in its seat. It is so proportioned as to float on the solution accumulating about it, but with so little buoyancy that it does not begin to float until the accumulation of liquid is considerable. The excess of liquid then flows back into the cell, which it could not do with the previous construction, as the latter closed too quickly.

Storage Battery Plate.—C. H. Whiting, New York. Patent 789,514, May 9, 1905. Application filed June 25, 1904.

The plate, as shown in Fig. 4, is of rectangular form, and is preferably made of thin metal, cast, stamped or otherwise shaped into form. It has an upper end piece *a*, which furnishes a support for the strips *b* which extend from it. Each strip has a number of perforations, which serve for ap-

plying the active mass, which, when spread on the two faces of each strip, passes through the openings and is thereby held in place. This is furthered by the arrangement of ribs *d* around the end piece *a* and each strip *b*, which, moreover, strengthens the plate and adds to its rigidity when it is made of thin material. The depending strips are fully separated from each other by an intervening slot *e*, which extends from the lower edge of the end piece *a* the full length of the strips. On account of this sub-division of the plate the expansion and contraction of the active material on one strip will not be transmitted to another, but will extend only over each individual strip. The expansion and contraction is, therefore, greatly reduced on such a plate, as compared with a plate in which the body is in one piece. Cross-ties *f* connect the various strips to each other at suitable intervals, thus preventing the plate from curving or bending, so as to destroy the parallelism of the various strips.

Protective Sheath or Envelope for Storage Battery Plates.—A. Meygret, Paris, France. Patent 789,557, May 9, 1905. Application filed May 9, 1904.

The inventor intends to prevent the loosening of the active material on the plates by enveloping it in a protective sheath in the nature of an impermeable film. This idea he has developed in several patents, which have been described in ELECTROCHEMICAL AND METALLURGICAL INDUSTRY. In the present process he produces the enveloping sheet by dipping the plate, when complete, with the active material on it, into a bath consisting of castor oil, pyroxyline and flexible collodion. The solution is formed by bringing the pyroxyline, preferably in the form of a jelly, into the solution of castor oil and flexible collodion. The sheath produced by dipping the plates into this solution is stated to be of an elastic nature, and to possess the property of not being attacked by the electrolyte. It has to be provided with a number of preparations or small slits, in order to allow access of the electrolyte to the active mass covered by it.

GALVANIC ELEMENTS.

Galvanic Battery.—D. L. Winters, Chicago. Patent 786,704, April 4, 1905. Application filed Jan. 3, 1905.

The battery is of the zinc-copper oxide type, and comprises a frame for the negative electrode and a holder or clip formed of a plate or bar of resilient material, which holds the electrode securely in its place, so that it can be readily removed and replaced.

MISCELLANEOUS.

Art of Treating and Utilizing Chlorine.—E. C. Paramore, Philadelphia. Patent 786,595, April 4, 1905. Application filed Oct. 5, 1903; renewed Sept. 1, 1904.

The present invention aims at increasing the bleaching properties and destroying the odor of chlorine, by subjecting streams of dry chlorine gas to electric discharges of high tension. The process is carried out by generating chlorine from black oxide of manganese and hydrochloric acid, passing it through a wash bottle containing sulphuric acid and forcing it by means of a pump through the apparatus, where it receives the electric treatment. This apparatus consists of a tube which has walls of dielectric material, which approach each other quite closely at about the middle of the tube, so as to force the gas to flow at that point in a broad and thin stream. Close to each wall, on the outside of the tube, is located an electrode of a current of high tension, which is discharged in sparks

through the walls of the dielectric and through the current of gas passing through the channel. Any liquid precipitated in the latter is removed by a trap, and the dry gas passes into a pipe, which carries it down to the bottom of a receptacle filled with the solution to be bleached. Rising above the liquid in this vessel, it is discharged into a pipe by which it re-enters the pump mentioned above, and is again electrified, after which it passes through the same circle of operations. The current employed may be either high tension, direct and intermittent, or alternating of high frequency. It is best derived from the secondary of a Rhumkorff coil. It is claimed that chlorine gas thus treated has greater bleaching power, little or no odor, and bleaches permanently the articles to which it is applied.

Notes on Electrochemistry and Electrometallurgy in Great Britain.

(From our Special Correspondent.)

THE PRESIDENTIAL ADDRESS AT THE INSTITUTION OF MINING AND METALLURGY.

Mr. William Freecheville's presidential address to this Institution—a copy of which has been kindly sent to me—is as capable of division into clearly marked sections as any stratified portion of the earth's crust. The first portion is a review of mining development within the British Empire, which deals with the financial assets of the Empire so far as metallic deposits are concerned. The second portion is devoted to some remarks on modern mining methods, in which the working of deep alluvial ground by pump dredges, and the design of compound centrifugal pumps are discussed. The third portion consists of a consideration of the giving of information to shareholders. Mr. Freecheville's opinions should serve to earn popularity among mining investors as distinct from speculators. "It may be stated, broadly, that a manager of a mine, in his periodical letters, gives free expression to his hopes and fears, and that any important change for better or for worse is, as a rule, foreshadowed in them a long time before it happens. Why should not the shareholders have this information, which is obtained at their expense and would be of much value to them to form just estimate of the value of their property?" * * * "I believe it would be found that the shareholder is nervous and timorous largely because he is kept so much in the dark, and that if he felt that all known information on the subject of his property was at his disposal, and that he could read, if he wished to, the manager's letters at the company's office, he would be much more stolid than many directors imagine."

The remainder of the address deals with the aims and objects of the Institution, emphasis being laid on the educative value of the papers deliberated no less than on the stand which the council of the Institution had taken with regard to defining what is actually comprised by the term "ore in sight," and the active influence it was bringing to bear on the question of mining education.

THE FARADAY SOCIETY.

The meeting held on April 4, was a "three-paper" evening, the first discussed being that of Mr. A. H. Hiorn's, entitled "Alloys of Copper and Bismuth." Professor Huntingdon, who was in the chair, opened the discussion by pointing out that previous observers had not recorded the eutectic point of pure copper and copper bismuth solution at 1,020° C., shown at D on the author's cooling curve. He also suggested that Mr. Hiorn's study would have been more complete had there been an inclusion of the results of an examination of chilled alloys. Dr. Desch concurred in this view of Professor Huntingdon's and spoke of the extreme complexity of the problems of crystallization. After some remarks by Professor E. Wilson concerning the effect of bismuth on the conductivity of copper, Mr. Hiorn in reply stated various experiments justifying his belief in the existence of the eutectic at 1,020° C.

Mr. E. Kilburn Scott's paper, which was printed in ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, April issue, p. 140, and to which the author gave a brief introduction at the meeting of January 31, was then discussed. It provoked a lengthy discussion in which different metallurgists spoke of their favorite furnace linings. Mr. Cremer commended sodium silicate as a binding material for use with carborundum. Mr. Morrison favored the use of tar, especially for high temperatures. Mr. Gaster spoke of siloxicon used with either binding material. He deprecated its use as a wash, recommending instead hard bricks made of this substance. Mention was also made of the fact by Mr. Morrison of the lack of exact data in the paper as to the actual temperatures employed, it being scarcely scientific to speak "highest possible" or "very high" temperature. Professor Dains sent a valuable communication to the discussion in the shape of some detailed descriptions and analyses of the various magnesite deposits at present available. Mr. Hutton complained of the absence of information in the paper respecting crystallized carborundum. Magnesite can be very easily fused in the electric furnace when it becomes fluid. Its conductivity, and that of the allied materials, was a most important point in regard to which very little work had been done. In his opinion the only satisfactory furnace lining was the material which the furnace itself produced.

The discussion on the first part of the paper by Mr. R. S. Hutton and Mr. W. H. Patterson, entitled "Electrically Heated Carbon Tube Furnaces," was unfortunately very brief—largely perhaps because the subject of tube furnaces is relatively a new one. Gratitude was expressed to the authors for their suggestion of the use of the water jacket and copper ends to the tubes. (The paper will be printed in full in one of our next issues.)

THE ALUMINIUM OUTLOOK IN THE UNITED KINGDOM.

At a meeting of the shareholders of the British Aluminium Company in April, Mr. J. D. Bonner said they had a surplus available for distribution as dividends on all classes of shares due to increased sales and reduction in cost of production. The profit for the year exceeded £55,400, compared with £34,143 in 1903, and he predicted that the profit for the current year would show an even greater increase. The demand for aluminium was growing, and necessitated the completion of the Loch Leven Power Works, of which the plans had been prepared. The company had a large and increasing business, and there was every indication that they would have a prosperous future.

THE ANNUAL MEETING OF THE UNITED ALKALI COMPANY, LIMITED.

Of the large English chemical manufacturing companies, the United Alkali Company is perhaps the second largest. It possesses works on the Tyne as well as in Lancashire and Cheshire. The annual meeting of the shareholders was held on March 24 last, and the speech of Mr. John Brock, the chairman, was interesting on account of its review of the commercial prospects of the industry generally. Mr. Brock said, "the deliveries of their goods had been somewhat lower in 1904 than in 1903, due mainly to the increase of manufacture in other countries, and to strikes and short time worked in various trades using the goods. Prices had remained in most cases at the low level of 1903, and for several articles had been even lower. In the metallurgical branch of their business, both prices and demand had favored them, and they looked forward to the future with confidence. They would have to spend money in the improvement of machinery and development in linking up the two properties in Spain by a tramway, by improving the means of the transit of the ore to the port of shipment, etc. The action brought against them by the Acetylene Company for alleged infringement of patents had been finally decided in their favor by the House of Lords. The action had involved them in heavy expenses,

which they had written off out of revenue. The gross profit was £411,584, or £26,399 more than in 1903, and the net profit (after payment of interest) £219,019. Adding £80,047 from previous account and deducting £15,000 transferred to debenture redemption fund, there remained £284,066. The dividend on the 7 per cent. preference shares was being paid, £50,000 was transferred to depreciation, and £43,762 carried forward.

THE CAPITALISTIC SIDE OF BRITISH ELECTROCHEMISTRY AND METALLURGY.

About the third week in February the writer purchased, as is his annual custom, the 1905 issue of Garske's *Manual of Electrical Undertakings*, a work which gives the latest return of each electricity supply and each electric traction undertaking in the United Kingdom, together with returns as to capital invested in and dividends in these and in manufacturing concerns. As the *Manual* is divided into the following broad divisions: (1) Light power and traction; (2) telegraph and telephone; (3) manufacturing and miscellaneous, and (4) directory, and as section 3 is not further sub-divided into its respective sub-sections, the writer proceeded to note down the names and capitals invested in concerns of electrochemical and metallurgical interest. These may be considered under four groups:

- (a) Electrolytic alkali and bleaching powder, makers of.
- (b) Batteries, primary and secondary, makers of.
- (c) Metallurgical undertakings.
- (d) Miscellaneous.

Treating them in the order given, about £1,066,000 sterling is invested in the electrolytic alkali industry in four undertakings. Almost the whole of the capital is accounted for by two firms, the Castner-Kellner Alkali Company, Ltd., and the Electrolytic Alkali Company, Ltd. The former, whose works are at Runcorn, Cheshire, have a share and debenture capital amounting to £700,000. Their dividend for the last financial year amounted to 4 per cent, as compared with 8 per cent for 1898-99, 5 per cent for 1900, and 6 per cent in 1901, 1902 and 1903. The Electrolytic Alkali Co., which works the Hargreaves-Bird process, has not been so fortunate. No dividends have yet been paid on 202,000 ordinary shares of £1 each, nor on the 7 per cent preference shares.

The second group embraces seventeen limited liability undertakings with an aggregate capital of £603,289. Of these the Chloride Electrical Storage Co., Ltd., has a total capital of £115,250. Last year 6 per cent was paid on £62,000 of preference shares, and 8 per cent on £33,250 of ordinary shares. The Electric Power Storage Co., Ltd., has a capital of £118,158. The dividends on the ordinary shares were 5 per cent in each year from 1892 to 1902, and 6 per cent in 1903 and 1904. The only other company in the group which calls for specific comment is the "D. P." Battery Co., Ltd., which, with a share capital of £10,000 and £20,000 debentures, paid a dividend of 12 per cent in 1901, 15 per cent in 1902, and 20 per cent in 1903 and 1904.

In the third group nine undertakings are embraced. These have an aggregate capital of £2,003,173. Over one-third of this sum, or £700,000 is invested in the British Aluminium Co., £400,000 of which represents share capital, and £300,000 debenture capital bearing interest at 5 per cent. An issue of a further £300,000 worth of 5½ per cent debentures has been authorized. Another undertaking with a large capital is the Leeds Copper Works, Limited. The issued capital amounts to £608,400. For the year ending December 31, 1903, which were presented on June 27, 1904, a deficit amounting to £13,885 was incurred, as against a deficit of £5,579 for the preceding year.

The fourth group of miscellaneous undertakings includes makers of electrolytic meters, ozonizers and firms whose work is associated with electrochemistry, such as the Electro-Peat Coal Company, Limited, whose prospectus was so severely criticised last year. The total capital invested in the nine companies of this group is £439,191.

Inasmuch as Mr. Garske returns the actual aggregate subscribed capital invested in shares, debentures, and loans of the 1225 electrical undertakings particularized in the *Manual* as amounting to about £277,000,000, it will be seen that electrochemical and electrometallurgical investments are not largely patronized by the British investor.

MARKET QUOTATIONS.

The nominal quotations in the chemical trade are still stable, but a slight rise in price may be expected if the cotton mills of Lancashire continue as fully occupied as at present. There are attempts being made in several parts of the country to introduce electrolytically prepared bleaching solutions for textile and paper bleaching as a substitute for chloride of lime. The success of these processes will depend on local costs for power and salt, and their immediate area of commercial possibility would therefore seem to be limited to the vicinity of the salt-producing districts.

Shellac is hardening again in price, being quoted at from 150 to 165 shillings per cwt. Copper sulphate is slightly lower at £21.17.6 per ton, but cyanides are unchanged. Para rubber is in good demand, the prices varying largely with quality; Brazilian varieties fetch 5s. 6d., while the cleaner rubber from Ceylon and the Straits Settlements is in the neighborhood of 6s. 3d.

Platinum is quoted at £4.26 per oz. Cleveland pig iron, after remaining under £2.10.0 until the middle of the month, rose to £2.13.0 by May 2. Copper continued to fall, closing at £65.15.0. In sympathy with this decline rod and sheet copper have also fallen slightly. Tin was the subject of a boom in price about the middle of the month, largely owing to market speculations. The high price of £1.45 per ton was reached on April 12; an abrupt fall of £5 followed in two days. April ended with the price at £138.10.0, an increase of £1 since March 31. Lead rose slightly during the brief days of the tin boom, afterwards receding to £12.17.0 for ingot, and £14.50 for sheet. Zinc and quicksilver are unchanged.

London, May 6.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

INDUSTRIAL APPLICATIONS.

Electric Furnace Work.—The present status of electric furnace working is the subject of a recent paper by C. F. Burgess, published in the April issue of the *Jour. Western Soc'y of Engineers*. The author gives an interesting and enthusiastic account of what already has been accomplished with the elec-

tric furnace, and points out that "while it is only in process of emerging from the laboratory stage it has already reached the dignity of an agent whose services can be measured in terms of that sordid but universal unit—the dollar." He analyzes the inherent advantages of the electric furnace, gives a classification of the different furnace types, and then briefly

discusses some details of construction. Concerning the protection from the air of the portions of electrodes projecting outside of the furnace, he mentions encasing in a thin iron covering or artificial water-cooling, and says that in some of his "experiments at the University of Wisconsin it has been found that certain fused substances could be formed on the surface, making a layer of glass, completely excluding the air and protective even at a white heat." The author considers that the ultimate industrial success of the electric furnace depends on continuous operation. He then points out the high efficiency of the electric furnace compared with other furnaces. He emphasizes its possibilities in zinc metallurgy. "The present methods of extracting zinc are notoriously inefficient. Not only is the 80 per cent efficiency of the electric furnace, as compared with the 3 or 4 per cent efficiency of the ordinary zinc furnaces capable of resulting in an economy, but various other advantages may be attained as well. The cost of zinc production under present conditions involves incomplete extraction from the ore, absorption of zinc by the walls of the retorts, rapid destruction of retorts, and losses in the condensation of zinc. Electric furnace methods present opportunities for materially remedying these defects. In laboratory trials, made at the University of Wisconsin, it has been found possible to completely extract the zinc, so that none of it remains in the charge or is retained in the walls of the furnace. No practical form of furnace for this purpose has been evolved, however, the principal difficulty being in effecting continuous operation, a requirement which is almost imperative."

Manufacture of Phosphorus.—It is well known that at the Niagara works of the Oldbury Chemical Co. an electric furnace process is now used for the manufacture of phosphorus. An account of a laboratory investigation on the manufacture of phosphorus is given in two papers by W. Hempel in *Zeit. f. Angew. Chemie*, 1905, Vol. 18, pp. 132 and 401, and abstracted in the *Jour. Soc'y Chem. Ind.*, February 28 and April 15. The author has investigated the Pelletier process (conversion of tricalcium phosphate into monocalcium phosphate by means of sulphuric acid and reduction of the product by charcoal). In his experiments he used an electric tube furnace. Woehler long ago proposed to reduce a mixture of tricalcium phosphate and silica with charcoal, according to the equation



But the process never succeeded, owing to the difficulty of attaining the requisite temperature or of finding vessels to withstand it. Electric heating, however, has lessened or removed these difficulties, and an experiment was made on this process. Gas began to be evolved at 700° C., and became inflammable at 1000° C.; phosphorus was detected at 1150° C., began to distil in quantity at 1200° C., and the distillation ended at 1450° C. The yield was 92 per cent, and very little was in the "killed" condition. Electric heating has lately been adopted in German works. The retorts are sheet-iron cylinders, lined with fireclay, through the lower part of which carbon electrodes are introduced. The materials are fed in continuously, and the residual slag continuously removed. Perfect dryness of the materials is an important factor in increasing the yield. In the second paper the author replies to some criticisms of Neumann. He has used an electric-resistance furnace, not a carbon arc, because the former is more certainly regulated. But he has not suggested that this should be used on a large scale. On the large scale internal arc-heating will be more economical than externally fired retorts. Further experiments in his laboratory have shown that Woehler's process, using arc-heating, is by far the best method of preparing phosphorus.

Yellow Arsenic by Means of the Electric Arc.—A paper, by A Stock and W. Siebert, published in the *Berichte*, 1905, Vol. 38, p. 966, and abstracted in the *Jour. Soc'y Chem. Ind.*, states that yellow arsenic can be obtained by the action of an electric arc between arsenic electrodes under carbon bisulphide. The arsenic volatilizes and is condensed and dissolved by the

carbon bisulphide. The anode need not necessarily be of arsenic, but might be a carbon rod. Fused arsenic becomes very brittle in cooling; it is, therefore, difficult to make the anode from the pure metal. The authors employed an alloy of arsenic and antimony. In the arc the antimony is reduced to a very fine black powder, absolutely insoluble in carbon bisulphide. The operation was carried out in a beaker containing 500 cc. of the solvent, the whole placed in a larger vessel filled with water and ice. Using a current of 12 amps., 5 grams of the alloy were decomposed in 5 minutes, when the experiment was interrupted to allow the solution to cool down. Working for a 1 per cent solution gives the best results. The solution, separated from the water and filtered, is colorless, but turns yellow after some time. At -80° C. all the arsenic crystallizes out from the solution. By evaporation of the solution the black modification of arsenic, almost free from sulphur, is obtained.

Electrolytic Treatment of Electrolytic Slime.—The interesting article of Mr. Anson G. Betts, which appeared on page 141 of our April issue, has been reprinted in form of a pamphlet with some additions. The latter are here noted. To the statement of the particular reactions of the finely divided metals as they exist in slimes, the following additions are made: Selenium is not dissolved from slime by ferric sulphate solution, nor by caustic soda and sulphur, or equivalent solutions; it easily passes into the slag in melting with nitre; in electrolytic parting, at least in the process described on page 145, it remains with the gold. Tellurium is dissolved from slime by the action of ferric sulphate solution, and is reprecipitated by metallic copper, analogously to silver. Copper slimes containing sulphur yield tellurium, but not silver, to ferric sulphate. The reaction holding silver back was given on page 143, top of first column. In melting, even with nitre, tellurium goes mostly into the dore bullion, and in electrolytic parting remains with the gold, from which it can be extracted with hot sulphuric acid. The following analytical data are given in an appendix:

Analysis of electrolytic antimony from trail slime—Ag nil, Pb nil, Bi nil, Cu 0.07 per cent, As 0.47, Sb 99.52. (The arsenic was introduced into the antimony for the most part from the HF used, which almost always contains arsenic and antimony.) Analysis of dore bullion from trail slime—Ag 78.94 per cent, Pb 17.56, Au 2.08, Cu 0.81, Sb 0.47, As nil. Treatment of copper slime No. 15 in Table I. (page 142). Extracted by caustic soda, 95 per cent of the antimony, no selenium, and 0.043 tellurium. Analysis of dore bullion—Ag 86.55 per cent, Bi 5.37, Cu 5.99, Au 1.62, Te 0.16, Se trace, Pb nil, S nil, Sb trace. Analysis of upper slag from melting to dore—Ag 0.11 per cent. Analysis of lower slag from melting to dore—Ag 10.76 per cent, Cu 8.79, Sb 1.48, Bi 1.79, SiO 20.40, Fe 17.81, Se 2.25, Te 0.84, Pb nil. Electrodeposited silver, tested for Cu, Bi, Pb, Sb, Se, Te, Au and S, none present. Fresh silver electrolyte contains about 7.5 per cent Ag, 15 per cent CH₃ SO₃; exhausted silver electrolyte contains about 1.5 per cent Ag, 15 per cent CH₃ SO₃.

Detinning Tin Scrap.—In the April issue of *Elektrochem. Zeit.*, H. Mennicke continues his article on the winning of tin from tinned iron scrap. He gives brief data on quite a number of processes which have been proposed in recent years, mostly from patent specifications; all of them are considered to be of no value for industrial purposes. He then deals briefly with various patents for details of construction of apparatus, and gives references to articles published on the subject.

Electrolytic Manufacture of Chlorates and Perchlorates.—A French patent of P. Corbin (339,251, Dec. 31, 1903) is mentioned in the *Jour. Soc'y Chem. Ind.*, April 15. The invention relates to the manufacture of chlorates by the electrolysis of neutral alkali chlorides. Resin is added in small quantities in the presence of compounds of metals of the alkaline earths, and, in addition, dilute hydrochloric acid is introduced into the

solution during, or at intervals in, the electrolytic treatment of the same solution.

Ozone for Water Sterilization at Paris.—In the London *Elec. Eng.* of April 14 E. Guarini describes the water sterilization works recently started at the municipal water works of Paris, at Saint-Maur. The plant treats up to 150 cubic meters of Marne water per hour, taken either from the slow sand filters of the city of Paris or from the river and filtered, without adding any coagulant, by two rapid-pressure filters filled with crushed flint. The ozonizer system used is that of Count de Frise. The results are stated to show that a plant of even much greater size can be worked by two or three men, and does not want more than about 129 hp. in all, pumping included, for the treatment of 1000 cubic meters per hour. No solid dielectric is used in the de Frise ozonizer; they are artificially cooled. Each cell is made of a horizontal brass trough, with a half-cylindrical cross-section fitted with a plate glass cover and a cast iron water jacket. The trough is earthed, and forms one of the poles. Across the trough at regular distances, half-discs of brass, with serrated circular edges and of 60 mm. less diameter than the trough, are suspended from the glass lid; they are connected to the source of high-tension currents through liquid resistances, each half-disc being connected to one liquid resistance. These resistances perform the part of regulators, preventing the tension of the portion of current allowed to each semi-circular pole from rising above the limit at which sparks or arcs would be produced. Silent discharges are produced between the sharp points of the semi-circular high-tension poles and the inner surface of the earth troughs, as shown in Fig. 1. The current of air circulating along the tube passes through the succession of half-annular discharges, which transform part of its oxygen into ozone. After its passage through each discharge the air heated by electrification is partially

cooled down by the cool surface of the trough. This cooling is periodically completed by means of surface condensers placed between the elements of each line of ozonizers. The ozonizers are placed in a dark room, so that the superintendent may judge from the blue-violet color of the flames whether the apparatus is working in good condition. The ozonizers are worked with tensions higher than 2000 volts. The ozonized air is used over again and again, the inlet of the ozonizer being connected with the outlet of the sterilizers, arrangements being also provided to free the air from moisture and to make up, by fresh air, the oxygen which has been consumed in the shape of ozone.

Two of the sterilizers erected at Saint-Maur are cast-iron vertical cylinders enamelled inside. They are built up in parts, 50 cm. high, between the flanges of which are fitted horizontal celluloid diaphragms perforated with a great number of small holes of 0.7 mm. diameter. Air and water ascend together from the bottom to the top of the sterilizer, and are intimately mixed at the passage of each finely perforated diaphragm. In a third sterilizer the water is injected in the shape of a fine spray into the mass of ozonized air. The spray collects in the lower part of the column as water, into which the ozonized air is forced through the apertures of a perforated diaphragm, which makes it bubble through the water before reaching the spray.

Another type of ozonizer is described by A. Breydel in *L'Eclairage Electrique*, April 20. This type seems to be adapted specially for experimental and therapeutic work. Special means for artificial cooling and drying are provided. To prevent any sparks, the two sets of aluminium plates between which the silent discharge occurs, are separated by glass plates.

Every aluminium plate is covered on both sides with glass plates of larger surface.

Production of Ozone.—In connection with the various apparatus for the generation of ozone from air for the subsequent utilization for sterilization of water, bleaching and other purposes, an account of an investigation by Wommelsdorf is interesting, which is given in *Annalen der Physik*, No. 15, 1904, and abstracted in Lond. *Elec.*, Feb. 24. The author studied the "noxious charges" which impair the efficiency of influence machines, and which are, therefore, avoided as much as possible by makers of such machines. These become a minimum at a certain distance between the plates, and that distance, therefore, brings about the maximum efficiency. At a certain smaller distance between the plates the loss by the "noxious charges" becomes very large. The external effect of the machine approaches, in fact, to zero, and the electrical work is all done inside the machine. When that occurs an enormous quantity of ozone is produced by the machine. This indicates a possibility of producing ozone in a much more direct manner than hitherto has been possible. An influence machine can be made into a combined generator, transformer and ozone tube, and it might even be made to act as its own aspirator. It could be enclosed, and the loss of ozone would be reduced to a minimum. It should be possible to generate ozone in a very economic manner.

Calcium Carbide.—The manufacture and consumption of calcium carbide in the world is discussed by L. Marmier in the March issue of *L'Electrochimie*. The consumption during 1904 is estimated as 90,000 tons. Sixty-eight plants are actually in operation, which could produce about 150,000 tons, but they are not working to their full capacity. There are said to be in operation 17 plants in Germany and Switzerland, 14 in France, 11 in United States and Canada, 8 in Austria, 8 in Sweden and Norway, 6 in Italy, 2 in Spain, 1 in England and 1 in Argentine. Germany manufactures 12,000 tons, and consumes 18,000 tons, of which 6000 are imported from Sweden and Norway, Switzerland and Italy. France and its colonies consume about 14,000 tons, made in France. The United States and Canada consume 16,000 tons, and produce 18,000 tons, of which 2000 tons are exported to Mexico, Cuba and South America, the latter producing 1000 tons and consuming 2500. Italy produces more than 20,000 tons, and consumes more than 17,000 tons. Spain produces and consumes 5000 to 6000 tons. England consumes 3500 tons and produces 1000 to 1500 tons. The balance is imported from Sweden and Norway. These countries produce 11,000 tons and consume only 1500 tons. It is estimated that the consumption of calcium carbide in the world will increase by 20 to 25 per cent during 1905.

Calcium Carbide as an Explosive in Mining.—The *American Journal of Science*, March, notices an article by Guedras, from *Comptes Rendus*, Vol. 139, p. 1225, on a method of utilizing the explosive force of acetylene for mining purposes. A sheet-iron cylinder is used as a cartridge. At its bottom are placed about 50 gr. of granulated calcium carbide, and above this in a separate compartment is a sufficient amount of water to react with the carbide. There is also an air chamber containing an electric fuse. The cartridge is placed in the hole to be exploded, the latter is closed with a wooden plug, and an iron rod attached to the cartridge for the purpose of piercing the water compartment is struck, thus liberating the acetylene. After this has been disengaged for about five minutes, the mixture of air and acetylene is exploded. The explosion causes the rocks to fly about much less than would be expected, but they are thoroughly broken up.

Electrolytic Rectifier Versus Motor Generator.—In the London *Electric Review* of Feb. 10, H. Boot gives an account of some tests conducted with an electrolytic rectifier for charging the accumulators of a large electric car. The amperes required were 50, and the voltage 118 when the cells were fully charged. The total cost of a motor generator plant would have been \$775, while the cost of a Nodom electrolytic recti-

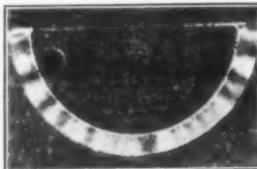


FIG. 1.—OZONIZING DISCHARGE.

fier was only \$340. The latter was adopted and proved very satisfactory in practice. The efficiency was found to be about 65 per cent and does not decrease during use. The rectifier has been in use since October, 1904, and shows no signs of deterioration. There is some evaporation taking place which requires adding distilled water. Two letters with notes on difficulties with electrolytic rectifiers are printed in the same journal of Feb. 17, to which H. Snowdon replies in the issue of Feb. 24, stating that he experienced no troubles. The successful application of an electrolytic rectifier for changing three-phase currents into direct current for use in a telephone station is described by R. Stosberg in *Elektrotech. Zeitschr.*, February 23.

Analysis of Refined Copper.—The principal methods now employed in large technical laboratories for the complete analysis of refined copper are the subject of a concise review by Mr. George L. Heath, of the Calumet & Hecla Smelting Works, published in the March issue of the *Jour. Amer. Chem. Soc'y.* The present tendency is to take separate samples for the estimation of each group of foreign elements by some special method of isolation. Analytical results are usually carried out to 0.0001 per cent. The author first gives exact rules for sampling. The following tests are made upon the finished metal: (1) Mechanical, (2) electrical, (3) chemical. Concerning the first two reference is made to a paper in Proc. Lake Superior Mining Institute, Vol. 7, p. 68 (1901). The author then deals with the chemical tests, assay of gold and silver, electrolytic estimation of pure metallic copper in commercial metal, estimation of oxygen, a rapid and exact method for the estimation of traces of sulphur in refined copper, various methods for determining arsenic, antimony and tin, selenium and tellurium, lead, iron, zinc, nickel and cobalt; bismuth. The author mentions incidentally a design for a rotating anode (Fig. 2), which has been found satisfactory for use with platinum cylinders as cathode.

A straight, stiff wire is bent back and forth at one end. A disc, the size of a quarter of a dollar, is cut from a sheet and is slit on radial lines to form ten propeller blades, and a small hole bored in the center, through which the bent end of the wire is passed and clamped by pressure. This is revolved to generate downward pressure, which takes the weight off the spindle and greatly lessens the friction.

Organic Chemistry.—J. Moeller's serial on electrochemical reactions in organic chemistry is continued in the April issue of *Elektrochem. Zeit.*, while the issue of April 1 of *Chem. Zeitschrift* brings the conclusion of an article by J. Mueller on the application of electrochemical reactions in organic chemistry on a commercial scale. His general conclusions are that primary reactions and, of the secondary ones, the substitution reactions, are at present scarcely of any value for industrial purposes of organic chemistry. There are a few technically useful cases of electrochemical oxidation of organic compounds, and there is no reason to expect much progress in this field in the near future. It is, however, quite different with electrochemical reduction, and the reduction of aromatic nitro compounds seems to represent a very promising field.

BATTERIES.

Nickel-Iron Alkaline Storage Battery and Accumulator Traction.—Jungner's German patents for this battery—which is known in this country as the Edison battery, while abroad it is sometimes called the Jungner-Edison battery—were acquired, as our readers know, by the Kölner Accumulatoren Werke Gottfried Hazen in Cologne. The director of this company, Dr. E. Sieg, recently delivered an interesting lecture on the development of this cell by his company, which is published in *Elektrotechnische Zeitschrift*, March 30. The first discussed in a general way the requirements of automobile batteries.



FIG. 2.
ELECTROLYTIC
ANALYSIS.

The power required for running an automobile is determined by two factors: first, the friction losses of all kinds, together with the efficiency of the gearing devices, etc., and, second, the air resistance. The power for overcoming the friction increases proportionally with load and speed, and amounts to about 80 watt-hours per ton-kilometer on average roads, so that if the automobile voltage is 80, the current consumption in amperes is approximately equal to the weight of the loaded vehicle in (metric) tons, multiplied by the speed in kilometers per hour. This item of power is of decisive importance for all speeds up to 15 kilometers per hour, so that the power for overcoming the air resistance is negligible except on stormy days. For higher speeds, however, the power consumed by the air resistance cannot be neglected, since it increases proportionally to the third power of the difference of the velocities of air and vehicle. For instance, for a light vehicle for two passengers, this item of power, running at 30 km. per hour, may amount to one-third of the total power; it depends, of course, greatly on the direction and the pressure of the wind. For practical purposes it is of special importance to know the capacity per unit of weight of the battery, for which the cost of operation is a minimum. The author has made such a calculation, with the aid of calculus under certain simplifying assumptions. He assumes a total weight of 250 kg. of vehicle and passengers; a run of 90 km. with one charge; a cost of maintenance of vehicle, excluding the battery, of 0.5 cent per ton-kilometer; and a cost of 5 cents per kilowatt-hours. Under these conditions he finds the following values, y , of the most favorable capacity in watt-hours per kilogram, corresponding to the values, v , of the speed of the vehicle in kilometers per hour:

$v = 10$	$y = 30$
15	31.2
20	33.3
25	36
35	37.8

In accordance with these results it has been the endeavor of storage battery manufacturers to increase the capacity per unit of weight, at the expense of life. The company of the author will soon place a lead cell on the market which yields 34 watt-hours per kilogram. He remarks that this type will not be more expensive per ampere-hour than the heavy types, but will be cheaper. The author thinks that the lead cell has not yet reached the end of its development for automobile purposes, "although even now in every case where the electric automobile may be used (*i. e.*, on roads of at least average quality for speeds not above 30 km. per hour and for runs not above 100 km. for one charge) it is cheaper than any other vehicle, especially cheaper than a horse-driven carriage."

The author then gives a long historical review of the development of the alkaline accumulator, and gives some theoretical considerations of the possibilities of the nickel-iron cell. For 1000 ampere-hours the lead accumulator requires theoretically (according to Faraday's law) 8.4 kg. active mass, the nickel-iron cell 3.4 kg. active mass. However, in the latter case the active mass must be mixed with some conducting material (graphite); this makes 5.9 kg. instead of 3.4 kg. Moreover, the average voltage of the lead cell is 2, that of the alkaline cell not more than 1.25. Hence 1 kg. active mass gives 2.38 watt-hours in the lead cell and 2.11 watt-hours in the alkaline cell. Further, in light lead cells the ratio of active mass to total weight of plates is 70 per cent, in the Edison cell 50 per cent. The author thus arrives at 166.5 watt-hours for the lead cell against 114 watt-hours for the alkaline cell for equal weights. (However, in these figures the difference in the weights of the electrolyte in both cases is neglected.)

The author then describes the troubles which his company had with developing the Jungner cell after they had bought the patents. These troubles had to do especially with the preparation of the active materials and the construction of the plates. The difficulties encountered seem to have been so

great that from the experiments they became convinced that by their method of construction it would be impossible to develop an accumulator equal to the lead cell with respect to lightness and far less one which would be superior. They therefore restricted their endeavors to the development of an accumulator which would be superior to the lead cell with respect to durability in spite of bad treatment. This cell gives only 10 to 12 watt-hours per kilogram (against 24 watt-hours for the Edison cell). Two modifications of Edison's construction are mentioned: They are sheet nickel instead of nickel-plated sheet steel (since the latter is said to be attacked in time), and they use nickel plates instead of graphite as addition to the active mass.

Edison Accumulator.—In *L'Eclairage Elec.*, of April 29, M. U. Schoop and C. Liagre discuss the question of the best electrolyte for a nickel iron alkaline accumulator. Potassium hydroxide has a maximum conductivity at 29 per cent, sodium hydroxide at 15 per cent, the maximum being greater for KOH than for NaOH. The reasons are given why it is best to use a 20 per cent solution of KOH, as is done by Edison. The authors give some practical rules how to handle alkaline solutions in experimental work in the laboratory. They finally mention the proposal of Michalowsky to use $\text{Al}_2\text{O}_3\text{K}_2$ as electrolyte. In this case it is possible to use zinc, since it is insoluble in this electrolyte. The reaction during charge is given as follows:



The two H atoms and the O atom are, of course, not set free, but represent the reduction and oxidation of the two electrodes. The KOH appears at the cathode and Al_2O_3 at the anode. If the electrodes are near enough to each other these two products mix, and $\text{Al}_2\text{O}_3\text{K}_2$ is regenerated. However, the low conductivity of this electrolyte is considered by the authors to be prohibitive for practical use.

Light Storage Batteries.—*L'Industrie Electrique* of Feb. 10, contains a note on a new lead accumulator called "E. I. t." Both plates are pasted, and it is claimed that the novelty rests in the use of special lead oxides. The useful average e. m. f. is stated to be 5 per cent higher than that of the ordinary lead accumulators for the same quantity of active material, and the capacity is said to be 33 to 50 per cent higher than in accumulators in which the ordinary pastes are used. According to tests made in Paris the battery has an energy per weight of 41.2 watt-hours per kilogram with an initial e. m. f. of 2.29 volts and an initial useful potential difference of 2.07 volts, the discharge being continued down to 1.7 volt at an average rate of 5.5 watts per kilogram. The density was 1.32 (35° Baume) at the beginning of the discharge, and 1.16 (20° Baume) at the end. This unusually high density of the electrolyte might explain the result of the tests, and it is very doubtful whether an accumulator with such concentrated acid has any long life. Reference is made to the use of a concentrated solution by Krieger in 1901 on an automobile. He covered 307 km. without recharging with an initial e. m. f. of 21.5 volts, and with an energy of 38 watt-hours per kg. His sulphuric acid had an initial density of 1.285 (32° Baume) which is less than that of the electrolyte E. I. t. Nothing was heard later of his battery. To this later note, Krieger replies in the same journal of Feb. 25. He says his battery was not put out of service by this single experiment. He adds, however, that he would not employ every day such a battery. If very great care is taken, he claims, it is possible to get 50 or 60 charges and discharges with such a battery.

The *Elektrotechn. Zeitsch.* of March 2, gives a review of the electrical exhibits on the International Automobile Exposition in Berlin, the author being C. von Groddeck. In reviewing the accumulator automobiles of the Cologne Accumulator Works of Gottfried Hagen, it is said that the older lead accumulators for automobiles of this firm give watt-hours per kg. The weight of an automobile for four passengers is

1500 kg.; the weight of passengers 400 kg., and the weight of the battery of 1700 watt-hours is 850 kg., hence the total weight 2.75 tons, allowing a single run of 80 km. without recharging on the basis of a consumption of 75 watt-hours per ton-km. on a level road. The newer lead accumulators of the same firm give 29 watt-hours per kg. For the same automobile as before one gets a single run of 120 km. without recharging. On the other hand, if one is satisfied with a single run of 80 km., the total weight of the automobile may be reduced by 350 kg. With the very latest type of this firm it is said that 34 watt-hours are obtained per kg. The lower weight of the newer types is obtained by the use of a very thin plate which is stated to be protected against buckling by mechanical construction. The increase of capacity is obtained at the expense of life. While the older batteries give 150 discharges before they have to be renewed, the newer ones give only 100 discharges. It is stated, however, that this company has found by experiments extending over several years that this shorter life is not prohibitive since the increased cost of maintenance of the battery of the newer type is more than counterbalanced by the smaller cost of maintenance of the rubber tires. Some details are given on mechanical construction of automobiles and on benzine dynamo electromobiles. Gottfried Hagen had also exhibited a battery of the Jungner system (competing with the Edison battery in this country); but it is said that the Jungner battery is still in the experimental stage and has not been so far developed that it can be used in practice. The firm states that the batteries are still more expensive than lead accumulators, and that not the same length of run is obtained with them as with lead accumulators. Some electromobiles exhibited by Ziegenberg were equipped with lead-zinc accumulators which "are claimed to give 50 to 70 watt-hours per kg., and to have an unlimited life, while the time of charging is only one-half hour." No further details are given.

EXPERIMENTAL AND THEORETICAL.

Electrostenolysis.—Electrostenolysis is the name usually applied to the deposition of certain metals in capillary tubes during the passage of the current. The deposition occurs, as a rule, only under circumstances capable of producing considerable endosmosis, namely, when the fall of the potential in the capillary is great. After the capillary has been lined or plugged with deposited metal its ends act as minute secondary electrodes within the liquid, giving rise to secondary cathodic and anodic reactions. The phenomenon is most easily demonstrated by using as capillaries the fine cracks caused by the plunging of a hot glass tube into water. Such a device was made use of by T. W. Richards and B. S. Lacy (*Jour. Am. Chem. Soc'y*, March), who investigated the fundamental question whether this phenomenon has any effect on the quantity of metal deposited on the cathode according to Faraday's law. This question is especially important, since the interposition of a porous cup (or system of capillaries) has recently been suggested as an essential part of an accurate electrolytic apparatus for measuring electrical quantity. The authors found that the complication of electrostenolytic deposition does not affect in any way the weight of the true cathode deposit or the exact application of Faraday's law.

Liquid Ammonia Solutions.—In the March issue of the *Jour. Am. Chem. Soc'y*, E. C. Franklin and C. A. Kraus publish a second paper giving the results of a very extended investigation of the conductivity of some 37 substances in liquid ammonia solution. The results are given in tables and diagrams. Some special observations are interesting; for instance, the cyanides of the heavy metals and cyanacetamide, when dissolved in ammonia, show the remarkable phenomenon of a decrease of the molecular conductivity with the dilution in the more concentrated solutions. As the dilution increases the conductivity passes through a minimum, and then increases with the dilution in the manner characteristic of salts in gen-

eral. The uni-univalent salts show a wide variation in conductivity and degree of ionization with the dilution. Tables and curves are given showing these relations and comparing the behavior of salts in solution in ammonia with their behavior in aqueous solutions.

Electrochemical Series of Metals.—The May issue of the *Jour. Am. Chem. Soc'y* contains an account of an experimental investigation by G. McP. Smith, on the reciprocal replacement of the metals in aqueous solutions. An abbreviated electrochemical series of the metals reads as follows: + K, Na, Ba, Sr, Ca, Mg, Al, Zn, Cd, Fe, Co, Ni, Sn, Pb, Cu, Hg, Ag, Pt, Au —. The author formed the metals in the following pairs to be reciprocally replaceable in aqueous solution, the metal first named in each pair being, under ordinary circumstances, more readily replaceable by the second than the second by the first: K — Na, K — Ba, Na — Ba, Zn — Cu, Cd — Cu, (Fe — Hg), (Fe — Ag), Hg — Ag, Hg — Pt, Hg — Au, Ag — Au.

Electrical Thermostat.—A simple electrical thermostat is described by Fred. A. Osborn in the April issue of the *Jour. of Phys. Chemistry*, as a simple, quick and yet accurate means of controlling the temperature in laboratory work in conductivity. The construction is shown in Fig. 3, where AA are platinum points; B, the storage battery of eight cells; B', a single cell; C, iron wire; D, a stirrer; E, a glass coil (16 cm. long, 9.5 cm. diameter), containing mercury; R, a relay of 20-ohm. resistance. The heating of the 50-liter bath is accomplished by means of one layer of iron wire of five turns, carrying a 3-amp. current from the eight cells. The bath is brought to

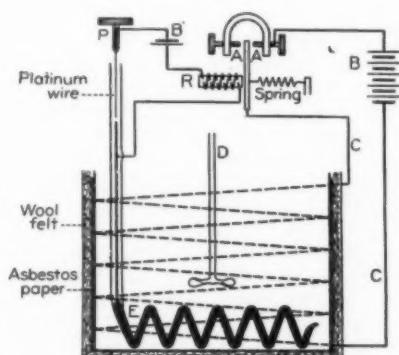


FIG. 3.—ELECTRIC THERMOSTAT.

within one-tenth degree of the required temperature, and then a very little adjustment of the screw P puts the bath into automatic regulation. The bath has many times been made self-regulating within fifteen minutes. The large volume of mercury and the very large surface of the worm combine to make the regulator very sensitive, the relay very often throwing the current off and on, while the Beckmann thermometer showed no change. On continuous runs of six or eight hours no change of 1/100 of a degree has been observed.

Atomic Weights of Sodium and Chlorine.—The May issue of the *Jour. Am. Chem. Soc'y* contains the full report on a very extended and extremely careful redetermination, by Theo. W. Richards and R. C. Wells, of the atomic weights of sodium and chlorine. The authors prove that the value for sodium from Stas's classical researches is nearly 0.2 per cent too high. The new values are:

Ag = 107.920	Ag = 107.930
Atomic weight of sodium.....	23.006
" " chlorine ...	35.470
	23.008
	35.473

Many other atomic weights are affected, in their second decimal places, by these results.

METALLURGY.

IRON AND STEEL.

Blast Furnace Practice.—A very entertaining lecture was given before the Franklin Institute the early part of this year, and printed in its *Journal* for February (reprinted in the *Iron and Steel Magazine* for May), by Edward A. Uehling, M. E. The subject was "The Fundamental Principles Involved in Blast Furnace Practice," and since the lecturer was in charge of the blast furnaces of the Bethlehem Steel Co. some years ago, he may be taken as speaking with authority. A very brief review of his principal points is as follows: The ore should not be too lean or too rich, but above all uniform in quality; the finer it is the easier it is reduced, but the more trouble there is in getting blast through the furnace and the more difficulties there will be from dust in the gases. It should be sized to at least a 2-inch round-hole screen; the worst possible mixture is coarse and fine in such proportions that the latter just fills the interstices between the lumps of the former; all that passes through a 1-25-inch mesh should be briquetted, or else smelted by itself in a specially designed furnace, the latter being probably the best treatment. Flux should be well broken up, of uniform size, and dust avoided; calcining before use is impracticable, because of it slaking in the air if not at once used. Slag acts as a filter to purify the iron globules passing through it, also as a blanket to keep heat in the iron and to protect it against oxidation by the blast; also as a remover of sulphur and a regulator of the silicon content of the iron. Mr. Uehling's statement that lime is the only ingredient of the slag which is efficient in removing sulphur is believed by many, but it has been shown the magnesia acts similarly in a low-alumina slag; the statement that alumina should be kept below 15 per cent is also open to debate, because slags as high as 25 per cent alumina work satisfactorily if silica is kept correspondingly low, i. e., in basic slags, alumina replaces silica. The fuel keeps the charge open and provides the heat; it should be in coarse, rough, uniform pieces. It should possess cellular structure, combined with good crushing strength. Mr. Uehling's opinion is that most of the silicon in the iron comes from the silica in the fuel ash, and that, therefore, a fuel with high silica ash will produce a high silicon pig-iron. Air should be regular in quantity, which is best attained by keeping the blowing engines running at constant speed, and allowing the pressure to rise to what it may; this is more desirable than working by constant pressure; small leaks in the blast mains may cause many per cent loss of efficiency in delivery to the furnace; it should be regular in temperature, which is best attained by using "equalizers," which will reduce variations of 100° in the blast to 10°. The blast should be dry; as much as 28 tons of water may be blown in in twenty-four hours in wet, hot weather. Removing this by drying should save some 4 per cent of the fuel consumption, but actually, as shown by Mr. Gayley's experiment, saves 25 per cent. Why, it is difficult to say. In Mr. Uehling's opinion the drying of the blast is second in importance only to the heating of the blast, and it will be generally and promptly adopted.

The lecturer then discusses, in a lucid manner, the chemical reactions and general running of the furnace.

Hardening of Steel.—Paul Lejeune has continued Le Chatelier's experiments on the speed of cooling of steel quenched or hardened in different liquids, and reports his results in detail in the April *Revue de Metallurgie*. In water, the specimen used cooled from 700° to 100° in 6.6 seconds, in mercury in 17.2 seconds, in alcohol at 21 seconds. The duration of cooling varies very closely with the viscosity of the liquid used, for in water, oil, gelatine and glycerine, with relative viscosities of 1, 6, 25 and 36, the relative times of cooling were as 1, 6, 15 and 36.

Forging.—The April number of *Revue de Metallurgie* contains a valuable memoir on the mode of action of the forging press and a study of the deformations of hot-compressed

metal, by M. Demozay. The tests were made on a 2000-ton press at the Holtzer steel works at Unieux. Numerous curves were taken of the pressures required to effect successive compressions. In general, the energy required is expressible as a function of the cross-sectional area of the bar compressed, the distance through which the press descends, and a coefficient K, which varies with the temperature of the ingot and the number of times the pressure is applied. Curves are given showing the variation of K with these conditions.

Aluminium Steels.—The assiduous metallographist, L. Guillet, has studied the micrography and physical properties of two series of aluminium steels (*Revue de Metallurgie*, April). The first series is mild steel with 0.08 to 0.16 per cent of carbon, and 0.51, 1.08, 2.05, 3.05, 5.08, 7.18, 9.25 and 15.03 per cent of aluminium; the second series carbon steels with 0.66 to 0.86 per cent of carbon, and 0.05, 1.05, 1.09, 2.89, 4.65, 7.0, 9.15 and 14.90 per cent of aluminium. Each steel was tested *au naturel*, forged tempered and annealed. Some twenty-five fine photo-micrographs illustrate the article. The conclusions arrived at are: (1) Aluminium has no important effect on the mechanical properties of steels as long as it is present in small proportion; above 2 to 3 per cent it causes great brittleness. (2) Up to 15 per cent of aluminium there is not found any combination of iron and aluminium; the latter simply goes into solution in the iron. (3) The solution of aluminium thus formed does not dissolve, causing the perlite present to take a special granular form, explaining the brittleness observed, and martensite is found after tempering only where there was perlite. (4) Free cementite is found, even in aluminium steels with less than 0.85 per cent of carbon. (5) The steels low in aluminium have very feeble hysteresis, which fits them for electrical machinery. (6) Aluminium steels with 1 per cent are cemented by carbon only half as fast as pure steels, and with 3 per cent only one-quarter as fast, while a 7 per cent steel could not be cemented; it appears that carbon is no longer soluble in iron containing already-dissolved a certain quantity of aluminium.

MR. GAYLEY'S DRY-BLAST PROCESS.

By the courtesy of the Council of the American Institute of Mining Engineers, we are enabled to give the following abstract from an advance copy of a discussion by Dr. J. W. Richards of Mr. Gayley's celebrated paper on the application of dry-air blast to the manufacture of iron. The full discussion by Dr. J. W. Richards will be published in the July issue of the *Bi-Monthly Bulletin* of the Institute. Dr. Richards' discussion is most instructive and interesting in two respects. First, it gives what appears to be a full explanation of the puzzling question why Mr. Gayley obtained such a far better result than could have been expected from theory or practice. Second, Dr. Richards' discussion is an instructive example of what can be accomplished by exact metallurgical calculations in the analysis of a process. Dr. Richards first states the exact data given by Mr. Gayley as to operation with dry-air blast compared with moist-air blast. He adds a few assumptions as to the composition of the ore, limestone and coke used and of the pig-iron produced, which correspond with sufficient exactness to actual furnace practice. On the basis of these data supplied and assumed he calculates the balance sheets of the materials entering and leaving the furnace per hundred parts of pig-iron produced for operation with moist blast and dry blast respectively. (In this calculation there is a poor agreement between the calculated volumes of air with the stated piston displacements. If the piston displacements are reliable, the delivery efficiencies are 73 per cent in pumping warm, moist air, and 83 per cent in pumping the cold, dried air. It appears more probable that the delivery efficiency is raised in the slower running by the amount just indicated than that the calculations of the volumes received by the furnace are grossly incorrect. The rather startling conclusion is thus reached, that the furnace received nearly as many cubic feet of dried air, measured at 25° F.,

as it did of moist air measured at 75° F., although the engines were running 15.8 per cent slower. The only explanation Dr. Richards has to offer for this is the increased delivery efficiency; but possibly some other factor may partly account for it.)

Dr. Richards then passes over to the calculations of the heat balance-sheet per 100 kg of pig-iron produced. One figure in this balance sheet enables one to check the calculations; this is the loss of heat by radiation, conduction, etc., which is calculated (by difference) as 77,101 calories with moist blast and 63,025 with dry blast; from the increase of the output from 358 tons to 447 tons per day one would expect a reduction of the radiation loss from 77,101 to 61,830 calories, which agrees well with 63,025, thus giving a good check on the general accuracy of the calculation.

This heat balance sheet is now the basis of the explanation of the whole matter. From it follows that the economy in heat requirements by using dry blast is due to six different causes, which are tabulated below; to understand this table it should be said that the total heat requirement of the furnace, when running on moist blast (the total heat received by it and developed within it), is 383,635 calories.

	Heat Saved.	Per Cent of Requirements.
On decomposition of moisture of blast.	11,287	2.95
On heat in waste gases.....	20,037	5.25
On radiation, etc.....	14,076	3.7
Better combustion of carbon.....	26,395	6.9
Smaller heat in slag.....	480	0.1
Less heat in blast.....	1,535	0.4
Total	73,810	19.3

Mr. Gayley had found that actually 19.6 per cent less coke per ton of pig-iron made were required. It is thus clear that of the total saving effected, less than 15 per cent is directly attributable to the absence of moisture in the blast; the other 85 per cent of the economy is due to indirect influences, viz.: (1) The heat in the waste gases is less, because the waste gases are less in amount, and therefore pass out cooled to a lower temperature; (2) the radiation loss is reduced, because the furnace smelts faster, and these losses are in actual amount proportional to the time rather than to the amount of material smelted, and (3) the carbon is consumed better, because there is much less carbon dioxide generated, and, therefore, there is less excess of carbonic oxide left unused in the waste gases—in other words, using moist blast, there is an excessive amount of carbon monoxide generated at the tuyeres in the effort to keep up the smelting temperature with the moist blast, and only a certain limited amount of this can be oxidized to carbon dioxide by the oxygen supplied by the reduction of the solid charges, while in using dry blast the temperature of the smelting zone is easily maintained, burning only 77 per cent as much carbon at the tuyeres (58.05 kg instead of 75.3 kg), and the carbon monoxide formed abstracts all the oxygen from the charges, and so is converted more largely into carbon dioxide than in the first case.

The whole question of economy obtained therefore converges towards the discussion of the generation of the heat necessary for smelting in the region of the tuyeres. To generate this amount of heat for the requisite temperature, with the production of no more carbon monoxide than is necessary to achieve reduction of the charges above, is the direction in which economy is to be obtained. The efficiency of hot blast is due to exactly this reason, that it increases the smelting power of the tuyere region without an increase in the carbon monoxide formed, and with a higher temperature of the gases in the tuyere region.

These points are then made the subject of further discussion, with respect to the increased output, and it is shown that the gaseous products of combustion, using dry blast, have 23.4 per cent more of their heat utilizable per unit of time for smelt-

ing purposes, and have an additional relative heat potential of 5.6 per cent to assist in imparting this heat more quickly, making a total relative smelting capacity of $123.4 \times 1.056 = 130.3$ to 100, or 30.3 per cent increase if the quantity of oxygen blown in per unit of time were constant. But, since the quantity of oxygen actually blown in per day in Mr. Gayley's experiment was as 100 for moist blast to 96.3 for dry blast, the rapidity of smelting should have been as 100 to $130.3 \times 96.3 = 100$ to 195.5, or a daily increase of 25.5 per cent.

Since Mr. Gayley obtained an increase of 24.86 per cent the views advanced by Dr. Richards give a satisfactory explanation of the increased smelting power of the furnace: that the heat saved by absence of moisture is directly utilized for increased smelting capacity, aided, furthermore, by higher heat potential, which of itself alone would increase the smelting rate about 5 per cent, the two factors working simultaneously and necessarily interdependently towards the total effect.

In conclusion Dr. Richards says that the increased efficiency obtained by Mr. Gayley could theoretically have been obtained by an increased temperature of blast alone, viz.: by using the moist blast at 597° C. ($1,107^{\circ}$ F.), instead of at 382° C. (720° F.). Such increase would produce the effects of quicker running and economizing coke to the quantity noted with dry blast, but would still leave the furnace subject to the irregularities inseparable from using ordinary air with its varying temperature and content of moisture. The increased regularity of running of the furnace and quality of product, due to uniform temperature of air supplied to the blowing engine and uniform temperature before the tuyeres, is the fundamental economic justification for Mr. Gayley's innovation; the increased rate of driving and economy of fuel alone could be obtained more cheaply by increasing the capacity of the stoves.

ZINC.

Zinc.—The decomposition and formation of zinc sulphate by heating and roasting has been the subject of a very extended experimental investigation of Professor H. O. Hofman, of the Massachusetts Institute, the results being given in the January issue of the *Bi-monthly Bulletin* of the American Institute Mining Engineers. The first part of the paper deals with the decomposition of zinc sulphate by heating in air. Dehydration is practically complete at 263° C. Decomposition begins at 532° C., and is complete at 739° . The second part of the paper deals with the decomposition of zinc sulphate by heating with carbon (reducing roast). The reaction of carbon upon zinc sulphate begins at 409° C., but is weak, and lasts only a short time; it grows stronger at 425° , 463° , 475° , 500° C., but weakens perceptibly after a few hours; only at 528° C. does carbon appear to become decidedly active, but even here the effect is at best very slow and imperfect, as it is opposed by the direct reduction of zinc sulphate to zinc sulphide. Under the most favorable conditions the 19.86 per cent of sulphur of zinc sulphate are reduced to 3.47 per cent; of this total 1.41 per cent is sulphide-sulphur, and 2.06 per cent sulphate-sulphur. The third part of the paper deals with the formation of zinc sulphate by roasting. The leading features of the sulphatizing roasts are given by the author in a table. The chief results are as follows: The amount of normal zinc sulphate soluble in hot water obtained in the tests is very small. Based upon 100 parts of zinc in the charge it reaches 9.07 per cent with raw blonde, and 15.92 per cent with dead-roasted mixed with a large excess of pure pyrite. Both extractions are too small to be of much practical value. The fundamental difficulty in obtaining a satisfactory percentage of extraction lies in two facts: normal zinc sulphate is rapidly decomposed at the temperature for roasting blonde; at the beginning of a roast, sulphur dioxide strongly predominates over sulphur trioxide. In the process carried out in the Harz mountains, the ore is roasted very slowly in heaps, which have to be turned three times: the first heap of 500 tons ore burns from six to seven months, the second fire lasts from six to eight weeks, and the third from four to six weeks. Normal and

basic sulphates are formed mainly in the fines, i. e., in the relatively cool cover, and these alone are leashed with water and sulphuric acid. The probable explanation for the formation of these sulphates is that zinc sulphate formed toward the hotter center of a heap is decomposed, and the sulphur trioxide, dioxide and oxygen rising attack the fines in the cool cover and form normal and basic salts, or normal salts alone, which are decomposed in part when the heat creeps up toward the end of the roast. The ratio of sulphur as basic sulphate to sulphur as normal sulphate increases with the temperature. Ferruginous (Warren) blonde is more difficult to roast than blonde running low in iron (Japlin), but the former gives, under similar conditions of treatment, a higher yield in normal sulphate, owing to the presence of isomorphous sulphide, the basic salts of which have a strongly sulphatizing effect when they are decomposed by heat.

Zinc.—The January issue of the *Bi-monthly Bulletin* of the American Institute Mining Engineers contains a paper by H. C. Meister on the zinc-smelting industry of the Middle West. The paper is mainly of a descriptive character. The author gives statistical data, and deals briefly with the processes of roasting and smelting, several types of furnaces being described. The number of retorts in operation in the coal-burning smelters in Illinois, Missouri and Kansas is 15,606, in the natural-gas-burning smelters in Indiana and Kansas, 37,480, total, 53,086.

Residual Zinc in the Retorts.—A valuable contribution to the subject of the state of combination of the zinc left in the retort residues is given in a letter of E. Schuchard to the editor of *Metallurgie*, and published in the March 8th number of that journal. From analyses of some 500 residues the conclusion is drawn that an average of 2.5 per cent of zinc is present in them; that if sufficient care in firing is observed the residues should never contain over 3.0 per cent of zinc, and that such statements as: "the residues contain 10 per cent and over of zinc," and "this zinc is mostly combined with sulphur," are statements of antiquated practice and kindergarten methods, which have no application at all to modern zinc smelting.

To determine the amount of zinc combined with sulphur in the residues, the sample is first washed with water, to remove the calcium sulphide which is always present. The residue is then treated with acetic acid, to attack and dissolve the zinc oxide, while zinc sulphide remains. In this way it has been determined that from 12 up to 43 per cent of the zinc in the residues is present as zinc sulphide, an average of about 80 analyses giving 31 per cent, a proportion which seems moreover to be independent of the total per cent of zinc in the residues at least from 0.15 to 7.00 per cent.

Furthermore, it is not true that unroasted sulphur in the roasted ore holds back twice its weight of zinc in the residues. Brandhorst has proved that a partly roasted blonde, with even 5.8 per cent of sulphur left in it could be so completely distilled that only traces of zinc could be found in the residue. In one residue tested there was present 14.58 per cent of calcium sulphide, 2.12 per cent of zinc oxide, 1.57 per cent of iron sulphide and 1.31 per cent of zinc sulphide, showing that very little zinc sulphide may be left even when the residue is rich in other sulphides. The observations agree very well with the opinions on the same subject by W. McA. Johnson, printed in our issue of January last.

MISCELLANEOUS.

Fire-Clays.—A paper, by H. A. Wheeler in the January issue of the *Bi-monthly Bulletin* of the American Institute Mining Engineers, deals with the fire-clays of Missouri. It may surprise some of our readers to learn that, among the industries based on the mineral resources of the United States, that of clay now ranks third, being exceeded in value of product only by pig-iron and coal. The value of pig-iron produced in 1902 was \$372,775,000; coal, \$367,032,069; clay products, \$122,160,531. About 10 per cent of the latter was firebrick. The author deals with the Missouri fire-clay industry and

market. The distinction is made between flint fire-clays and plastic fire-clays, their occurrence, chemical composition and physical properties being discussed.

Plasticity.—We have received a reprint of a paper on the colloid theory of plasticity by Dr. Allerton S. Cushman, chemist of the road material laboratory of the Department of Agriculture. The paper was presented before the American Ceramic Society. The main points brought out by the author are as follows. Both plasticity and binding power are merely manifestations of a colloid modification of matter which exists in rocks and clays. The activity of these useful qualities depends upon the characteristics of the special colloids that may be present, as well as upon their past history, and the modifying effect upon them of saline and organic solutions. Absorptive qualities of clays, such as their ability to stick when touched with the tongue, and as exhibited by their occasional use as "lakes," clarifying agents, etc., are to be ascribed to the same cause. In conclusion the author says that in bringing out the above points, he does not desire to minimize the importance of the effect of the shape and size of the grain on the useful qualities of clays.

Utilizing Waste Heat.—While the utilization of the waste gases from blast furnaces is at present in the front rank of interest, the utilization of the waste heat from coke ovens is also a matter of considerable importance. The February issue of *Mines and Minerals* contains some illustrated notes on the general arrangement of apparatus for this purpose, and on tests made at the Victoria-Gatesfield Colliery of the Priestman Colleries Co., of England. A special object in these tests was to compare the results obtained with water-tube boilers in comparison with boilers of the Lancashire type. The figures given in the article show that "the heating surface in the Stirling boiler abstracts more heat from the gases than the heating surface in the Lancashire boilers, and that although the mean temperature of the gases in contact with the surface in the Lancashire boiler is higher than the mean temperature of the gases in contact with the surface in the Stirling boiler, not only was the normal capacity of the Stirling boiler reached, but it gave an evaporation approximately 28 per cent in excess of that obtained with the Lancashire boilers, per pound of coal coked." The heating surface for best efficiency with waste-heat boilers should be greater than for coal-fired boilers.

RECENT METALLURGICAL PATENTS.

ROASTING.

Frederick J. Falding (788,008, April 25) patents details of construction of a roasting furnace of the well-known type comprising a series of superimposed hearths and a series of rotating stirring arms, arranged above the hearths and carried by a central shaft. The object is to so connect the stirring arms with the central shaft as to facilitate the cooling of arms and shaft, and also facilitate any necessary repairs of the arms,

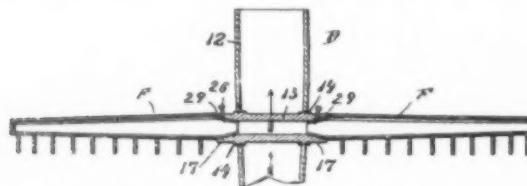


FIG. 1.—CONNECTION OF STIRRING ARMS WITH SHAFT.

while the necessity of repairing the shaft itself is largely done away with. For each hearth a pair of stirring-arms is provided, secured to the shaft diametrically opposite each other. For this purpose the shaft is perforated at two points opposite each other, and in these perforations are secured fittings 13

in the form of hollow cylindrical sleeves. The simplest construction is shown in Fig. 1, which refers to the case that it is only necessary to cool the shaft D. The illustration shows the annular bosses 14, and the projecting socket ends 17, and the stirring arms F, which are provided with shoulders 29 to abut against the ends of the fittings 13. The arms are held in place by the pins 26. The arrows indicate the flow of the cooling liquid through the shaft around the fittings 13. By the use of the fittings 13, which are held in place in the shaft merely by being tightly fitted and without any positive means, the sleeve, when deteriorated, or when not properly fitting, owing to the deterioration of the shaft, may be readily withdrawn from the shaft by tongs passed through the apertures in the furnace-wall, and another sleeve, having bosses 14, of the proper dimensions inserted. By the employment of such fittings the necessity of cooling down the furnace and withdrawing the shaft for the purpose of inserting a new shaft, is largely obviated. A more complicated construction, comprising partitions in the shaft, in the arms and in the fittings, is described in the patent, for the case that it is necessary to cool both the shaft and the stirring arms.

Albert C. Johnson (786,905, April 11) patents a rocking, or tilting, roasting furnace of cylindrical shape with a horizontal axis. Within it are provided successive longitudinal and inclined shelves, one above the other. The alternate ends of the shelves are free, so that the ore having passed lengthwise along one shelf to its free end, drops onto the next shelf and passes along the latter back through the cylinder to the other end. Each shelf is curved, being higher in the center, i. e., the cross-section of the cylinder shows the cross-sections of the shelves in form of convex curves. When the furnace is rocked

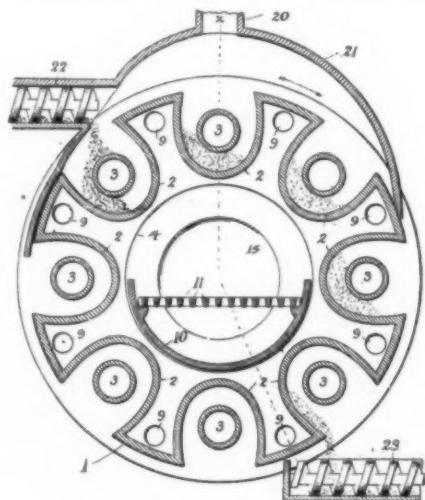


FIG. 2.—ROASTING DRUM.

the ore is carried from one side of the shelf over to the other side, and at the same time it is advanced towards the free end of the shelf.

J. W. R. Laxton (789,371, May 9) patents the revolving roaster drum shown in cross-section in Fig. 2. The drum 1 has a much greater diameter than axial length, and has a large number of pockets 3 in its periphery. The heat is supplied from the fire-pot 10 within the drum, and supported on the outside by a framework. The fire is built upon the grates 11. The ore is supplied through 22 into a pocket, which retains the ore until the drum has made one-half revolution. It is then delivered by gravity into the conveyor 23.

Peter A. Wagner (789,303, May 9) endeavors to prevent the loss of metal, due to the escape of metallic vapor passing with the products of combustion out of the furnace stack. For this purpose he inserts, between roasting furnace and stack, a con-

densation and collecting chamber, filled with water to a certain level. The products of combustion pass through this chamber before they get to the stack, and are condensed in this chamber.

Seely B. Patterson (787,540, April 18) roasts ore in a stack furnace without solid fuel or fuel gas within the ore. The column of ore is first subjected throughout its length to the action of hot air for a certain time, after that the lower portion of the column is treated with steam for a certain time, then follows again treatment with hot air, and so on. The following equations are given for the action of the hot air:



and for the action of the steam



WET PROCESS.

When a solution is introduced into the bottom of a pulp tank for leaching, a lead conduit is generally used with perforations, through which the solution is passed into the tank under pressure. The lead is sometimes so soft that the orifices are gradually enlarged until a slot is formed in the pipe, and the pipe becomes useless. Chauncy E. Dewey (787,902, April 25) therefore provides the pipe at intervals with orificed nozzles of sufficient length to cause the agitating fluid to pass upwardly into the tank in vertical jets. The tank is V-shaped in cross-section, the arrangement being clearly shown in the above Fig. 3.

G. H. Waterbury (788,443, April 25) treats copper ore by the following wet process: The pulverized ore is placed in a tank containing water saturated with sulphurous acid, and containing a small quantity of sulphuric acid. Air and steam are then introduced at the bottom of the tank, whereby the copper is dissolved. The solution is then passed into the precipitating tank, filled with particles of aluminium and steel in such a way that the solution can freely circulate therethrough. Air and steam are then introduced at the bottom of the tank, and passed through the solution, whereby the copper is precipitated and settles on the bottom of the tank.

LEAD CONTAINERS FOR ACIDS.

In order to increase the capability of ordinary commercial lead to withstand the corrosive effect of acids, H. E. Miller (786,581, April 4) proposes the following treatment: The lead is oxidized, preferably to the form of litharge, until about 95 per cent are oxidized. The oxide and residuum are then separated and the litharge is reconverted into metallic lead, "which will be found to have acquired a capability of resisting the corrosion of acid equal to that of the most satisfactory specimens, regardless of its natural source or previous process of manufacture, so that the metal resulting from this process is of uniform and high excellence in the desired characteristic."

BOOK REVIEWS.

ELECTRIC FURNACES AND THEIR INDUSTRIAL APPLICATIONS. By J. Wright. New York: The Norman W. Henley Publishing Co. Illustrated. Price \$3.00.

That which may be described as the "scissors and paste" type of book is usually looked upon with something akin to

contempt. It is regarded by many in somewhat the same light as an index—very useful, but requiring only a low order of ability to turn out. This way of looking at the subject is altogether wrong, for the making of a good index requires no small ability, and the skillful handling of scissors and paste deserve high praise.

"Electric Furnaces and Their Industrial Applications" is a book of the scissors and paste variety, but we regret that the author has failed altogether to produce a useful work, although there cannot be the least doubt that a book covering the subject would be very welcome. Although Mr. Wright has apparently made a most exhaustive catalogue of the technical and patent literature of his subject and has included in his book a large number of furnaces chiefly distinguished by their ingenious impracticability, his information is so inaccurate and the carelessness of his descriptions so marked throughout that it seems difficult to recommend the book. A few examples taken at random will serve to illustrate the general character of the work. In describing the manufacture of carborundum he says:

"The subsequent conversion, which occupies about 36 hours, results in some 2 tons of carborundum, as against a theoretical yield of 4 tons, from which it will be seen that the process is anything but efficient."

A carborundum furnace turns out much more than 2 tons of carborundum in 36 hours, as Mr. Wright might easily have discovered from his own figures, given two pages further on, where we learn that in 1901 with 2000 horse-power the annual output was 1690 tons. A simple calculation shows that a 1000-horse-power furnace turns out about 3.5 tons in 36 hours.

Turning to the manufacture of siloxicon, we are told that it is made from a mixture of "one part carbon to two parts silicon" (*sic*). When siloxicon is heated to 7000° F., "siloxicon vapor" (!) is driven off. In the description of Acheson's furnace for boiling carbon articles we learn that the latter are embedded in a heating resistance composed of "carbon and silicon."

It is interesting to find that of the various electric furnaces used for the manufacture of steel, "the Gin furnace * * * is probably one of the simplest in point of application." The author should explain in detail how in "Mr. Keller's electric blast (*sic*) furnace" the "heating effects" of the electrodes are "equalized by means of an ammeter included in each circuit." The induction furnace of Kjellin, as described at one place, is an astonishing apparatus, consisting of "an annular or helical channel in a refractory base filled with a conducting or semi-conducting medium, which constitutes the furnace charge and has a heavy current induced in it by a surrounding coil of many turns, carrying an alternating current."

Similar examples might be infinitely multiplied; but enough have been given to indicate the inaccurate and careless writing which characterizes the book. The work may be of some use as a catalogue of electric furnaces, practicable and otherwise, though even this is doubtful since references are rarely given which would enable the reader to refer to original descriptions. Certainly the book should not be placed in the hands of students who are desirous of obtaining accurate information.

D'Arsonval Galvanometers.

The Leeds & Northup Co., of Philadelphia, who, at the St. Louis Exposition, received a grand prize for their electrical measuring instruments, exhibited in connection with the exhibit of the National Bureau of Standards, have for a long while paid special attention to the design of the D'Arsonval galvanometers. After having placed several types of this galvanometer on the market they have now constructed an instrument ("type P") which combines the good qualities of their former types with extreme simplicity and compactness.

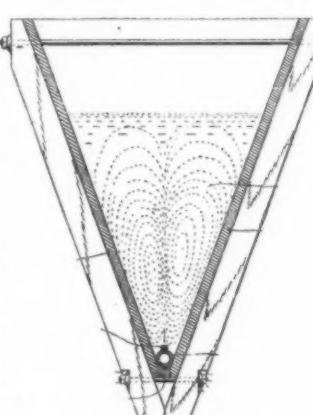
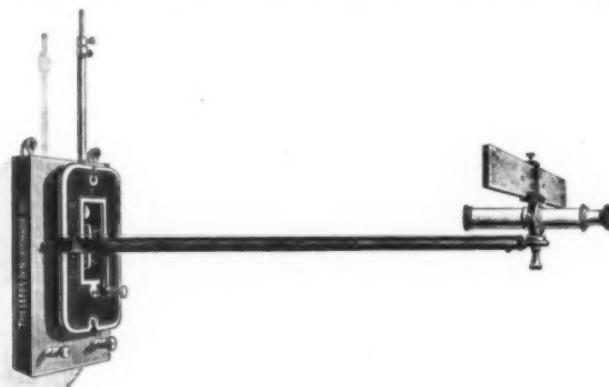


FIG. 3.—LEACHING TANK.

of construction. On account of its production in quantity it is sold at a low price. As a result of its very simple design it is very easily set up, easily manipulated and all working parts can be readily gotten at for inspection or repair so as to appeal to the student beginners, while its reliable working qualities commend it to the confidence of experienced investigators. This type of instrument is sold either in tripod form to be placed on a table or for suspension on the wall. In the latter case it is only necessary to drive two screws into the wall and hang the galvanometer up on them by means of two hooks in the backboard. By screwing one or two of the screws in or out it is easily made to stand perpendicular and allow the coil to swing free. The latter form of the instrument is shown in the adjoining illustration.

A great advantage is that the moving system is always entirely visible. Should it become necessary, it is most easy



GALVANOMETER.

to remove the telescope and scale arm and to take off the front plate, whereupon the coil is directly accessible.

The deflections are approximately proportional to the amperes or for ballistic measurements to the coulombs discharged. The system is well damped, so that it does not oscillate but make its deflection quickly, and comes promptly to rest either deflected or at zero.

A strong suspension is provided which allows no zero shift. The suspensions are consequently not easily broken, and when broken can be easily replaced; the only tools required for the latter purpose are a pair of forceps and a watchmaker's screw driver. The usual suspension is a heavy phosphor bronze strip, rolled from a wire of 0.003-inch diameter, and the coil carries, permanently attached to it, a copper rectangle which makes it nearly dead beat. It is thus absolutely free from zero shift. The coil resistance is about 100 ohms, and the sensibility such that 1 volt through 80 megohms will cause a deflection of 1 millimeter with the scale at 1 meter distance, or one-half millimeter on its own scale, which is one-half meter from the mirror.

By using lighter upper suspensions (which can be easily done) the sensibility can be very much increased. With an upper suspension of phosphor bronze wire, .0015 inch diameter, the sensibility will be such that 1 volt through 150 megohms will cause a deflection of 1 mm., or more with the scale at 1 meter's distance. The zero shift on full scale reversed deflections will generally not exceed 1 mm.

With an upper suspension of phosphor bronze ribbon rolled from strip .0015 inch diameter the sensibility will be such that 1 volt through 400 megohms will cause a deflection of 1 mm. or more with the scale at 1 meter's distance. The zero shift on full scale reversed deflections will generally not exceed 3½ mm.

There is an ample coil clearance provided so that no delicate adjustment is necessary to get the coil to swing free. The scale is large and clear and very easy to find and to read.

Furnace Door Arch-Plate.

The accompanying illustrations show the Johnson patent arch-plate made by the Wellman-Seaver-Morgan Co., of Cleveland, for the purpose of facilitating the work of repairing and rebuilding furnace-door arches. It is made of cast steel, and it is hence a permanent appliance which can be utilized on short notice. The arch-plate fits on the ram of the charging machine, and can be quickly picked out by it or detached as desired. The furnace door



ARCH-PLATE.

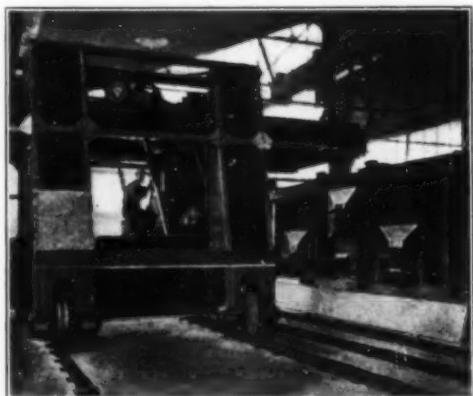
is raised out of the way and the charging machine inserts the plate in the charging opening of the furnace, holding it there in proper position until the repairs are completed, when it is withdrawn and detached from the ram of the charging machine.

The arch-plate serves a double purpose.

First, it forms a shield against the heat from the interior of the furnace, thus enabling the work of repairing the arch to be carried on without shutting down the furnace. In the old method of repairing arches it has been necessary to build a temporary protecting wall or bulkhead of brick, and on account of the heat this must be done with long-handled tools, making the process not only awkward and tedious, but also expensive, as it necessarily delays the furnace. The use of the Johnson arch-plate does away with all this.

Second, the Johnson arch-plate serves as a form on which the arch can be expeditiously relaid, supporting it during construction. The flange serves as a stop for the brick in laying the arch.

Work which would ordinarily require hours in the old way



JOHNSON ARCH-PLATE IN USE.

can, by using this arch-plate, be done in a small fraction of the time, while the charge of steel is being melted down and without any delay to the furnace.

An Improved Multiple-Rider Carrier.

The accompanying illustration shows an improved multiple-rider carrier for button balances, just placed on the market by William Ainsworth & Sons, of Denver, Col.

The weights or riders are each carried by an individual arm

and cannot become displaced except through gross carelessness.

The arms are numbered in their front surfaces to correspond with the weight of the rider carried, and pivoted at the rear, so as to just swing clear of the comb-shaped bar below the stirrup, and are operated by a single rod with a thumb piece on the end of it extending through the case. When the arms are up the riders are carried by them far enough above the comb-shaped bar so as not to interfere with the oscillations of the beam.

In operating, it is only necessary to move the rod to the right or left until the figure corresponding to the weight of the rider to be shifted, stands opposite to the index pointer shown to the left of the frame carrying the arms; then give the rod a slight turn and the arm carrying the rider is swung downward, shifting it on the comb-shaped bar.

When the weighing is completed, a glance at the figures on the arms that are down shows the combined weight of the riders on the bar. A slight turn of the rod resets all of the riders simultaneously.

The carrier can be operated with great speed and certainty, and the riders can be used for an indefinite length of time without perceptible change in weight.

Industrial Notes.

The New York office of the ROBERTS CHEMICAL Co. has been moved from 40 Wall Street to 60 Wall Street, where a more commodious suite has been secured on the twenty-fifth floor, from which is obtained an impressive view of New York harbor and surroundings.

Messrs. P. BLACKISTON'S SON & Co., the well-known publishers of scientific books in Philadelphia, have sent us a list of the international atomic weights for 1905, reprinted from the *Journal of the American Chemical Society*, Vol. 27, No. 1. This list is printed on pasteboard and may be hung up for use in the laboratory.

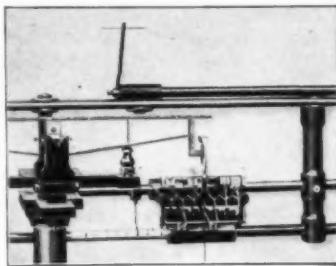
BLOWING ENGINE.—The Republic Iron & Steel Co., Youngstown, Ohio, has placed an order with ALLIS-CHALMERS Co., of Milwaukee, for one horizontal cross-compound condensing Bessemer blowing engine. The high-pressure cylinder will be 46 inches in diameter, the low-pressure cylinder 88 inches, and the two air cylinders each of 76 inches effective diameter. The stroke is to be 60 inches. The engine will be capable of delivering 24,000 cubic feet of free air per minute at a pressure of 28 pounds per square inch. The enormous size of this machine makes the order worthy of special note.

VANADIUM.—We have received from Mr. J. BAXERES DE ALZUGARAY a pamphlet on vanadium, its recent history, treatment, uses and market. The author first gives some historical notes on his intimate connection with the metallurgy of vanadium. On account of its high melting point it is preferable to use in practice ferro-vanadium alloys of lower melting point; the author recommends a 10 per cent alloy as the best for general use. The iron contained in the ore is not separated, but left to be precipitated together with the vanadium oxide to prepare ferro-vanadium from the reduction of this mixture. The ore is first fused with a suitable proportion of nitro cake, which is easily obtained at a low cost from nitric acid works.

This fused mass, containing iron and vanadium sulphates, is lixiviated with hot water, and from the solution a mixture of iron and vanadium hydroxides is precipitated by means of soda lye. The precipitate is collected in a filter, dried, and then reduced in an electric arc furnace with a reducing agent, or reduced by means of aluminium. While vanadium was formerly believed to be scarce in nature, the author states that vanadium ores, such as lead vanadate (vanadinite), lead-cuprovanadate (descloizite), and the vanadium-aluminium-silicate, known as roscoelite, are by no means scarce, so that the industry may count on a plentiful supply of ore. The author then discusses the applications of vanadium in the iron and steel industries. The introduction of vanadium into all the usual brands of steel, wrought and cast iron is stated to increase the malleability and the breaking strain by 90 per cent, and even further. "Crucible steel of a poor quality mixed with ferro-vanadium has produced a metal with a breaking strain of 61.57 tons (137,915 pounds) per square inch, and with an elongation of 23 per cent. The steel used to produce it broke before the addition of vanadium, under a load of 31.14 tons (69,753 pounds) per square inch, and had an elongation of 16 per cent." Several other examples are quoted. "The introduction of vanadium renders steel very mild when annealed and very hard when tempered. Armor plates can be produced of vanadium steel with an extremely hard surface, and with a soft backing. The superior ductility of this soft backing of vanadium steel would avert the splintering of the hardened plates and shields when struck by projectiles." The author emphasizes the great suitability of vanadium for self-tempering steel tools, but strongly urges to use in all cases pure ferro-vanadium, since impurities are likely to counterbalance the good effect of the vanadium. Vanadium-aluminium is briefly mentioned. "Copper-vanadium is possessed of great resistance and hardness. These alloys are suitable for the manufacture of guns, propeller blades, valves, and for many other uses in which a hard copper alloy possessing great tensile strength is required." The price of a 25 to 30 per cent ferro-vanadium, it is stated, was \$8.75 in 1893, and now is \$2.50. The author estimates that the vanadium contents of ferro-vanadium is now generally quoted at \$10.00 per pound.

The GENERAL STORAGE BATTERY Co., of 42 Broadway, New York, have issued a handsomely illustrated pamphlet, giving description, standard sizes and prices of the Bijur storage batteries, "high-duty" type, for stationary service. A description of this battery was given on page 203 of our last issue.

LARGE PUMPING ENGINES.—The city of Montgomery (Ala.) has recently placed an order with ALLIS-CHALMERS Co., of Milwaukee, for a horizontal duplex double-acting plunger pump, directly driven by a horizontal cross-compound Reynolds-Corliss condensing engine. This engine will have a capacity, against a total net head of 254 feet, of 8,000,000 United States gallons every twenty-four hours, when operated at a plunger speed not exceeding 360 feet, or 60 revolutions per minute, and supplied with steam at a pressure of 125 pounds per square inch at the throttle. This pumping engine is guaranteed to develop a duty of 135,000,000 foot-pounds for each 1000 pounds of dry steam consumed by the engine when operated at its rated capacity under contract conditions. The cylinder will be fitted with Reynolds-Corliss valve gear, especially arranged for this type of engine, and having independently adjustable cut-offs for each cylinder, the high-pressure valve gear being also under the control of an adjustable speed governor, provided with suitable mechanism for varying the speed of the engine between certain limits. The steam and exhaust valves of each cylinder will be operated by independent eccentrics. The total weight of the pumping engine is to be 230,700 pounds. The pumps will have a suction valve area of 297 square inches, and a discharge valve area of 297 square inches for each plunger, or 200 per cent of the area of the plunger.—The American Steel & Wire Co. has ordered for its American Works at Cleveland, Ohio, a 6,000,000-gallon



MULTIPLE-RIDER ARRANGEMENT.

pumping engine, which will also be built by Allis-Chalmers Co. The steam end of this pumping engine is a "heavy duty," horizontal, cross-compound Corliss condensing engine, with jacketed steam cylinders. The engine frames are a combination of the "heavy duty" and "reliance" type, having the slide cast solid with the frame, and a heavy foot extending down and resting with a broad base upon the foundations. The housing is also carried outside of the crank, as on the "heavy duty" frame, and a second slide housing is cast on to the frame for the attachment of the pump chambers; this pump end of the frame having a bored slide for the plunger cross-head. This design provides for the attachment of each steam cylinder and the corresponding pump cylinder to one and the same engine frame at opposite ends, providing an ideal and simple transmission for all the working stresses. The pumps are double-acting, with outside, center-packed plungers. The suction air chambers of the pumps are of special design, and insure absolutely the prompt and complete filling of the pumps on the suction stroke, even under very high suction lifts. The valve area and all waterways through the pumps are made very large, in proportion to the amount of water to be handled. The discharge air chambers are very large, and their effectiveness is greatly increased by large equalizing pipes, which connect them.

On the occasion of the recent International Railway Congress in Washington the various WESTINGHOUSE COMPANIES have issued an extremely neat and profusely illustrated booklet on the "Westinghouse Companies in the Railway and Industrial Fields," with an excellent portrait of Mr. George Westinghouse as frontispiece. While the booklet appeals in the first line to the railway and tramway engineer, it should be of great interest to every engineer on account of the historical notes contained in it on the evolution of the different Westinghouse Companies.

Personal.

Dr. CHAS. F. CHANDLER, of Columbia University, widely known for many years as one of the most prominent representatives of chemical and electrochemical science in this country, was married on May 24 to Miss Augusta Polhemus Berard, of New Hartford, Conn.

Mr. WOOLSEY MCA. JOHNSON has accepted a position as superintendent of the Lungwitz Reduction Co. This company has a large zinc blast furnace installed at Warren, N. H., to operate under the Lungwitz patents. The process in which the shaft is placed under a pressure of 45 pounds per square inch, was noticed in Dr. Franz Meyer's article on zinc metallurgy in our January issue. The furnace is designed for the treatment of ore from the Warren mine.

Dr. HENRY COOK BOYNTON, instructor in metallurgy and metallography in Harvard University, was awarded with a Carnegie Research Scholarship at the recent annual meeting of the Iron and Steel Institute in London. Dr. Boynton has already done much valuable research work in the field of the metallography of iron and steel.

Dr. CHARLES A. DOREMUS, chairman of the New York Section of the American Electrochemical Society, sustained a severe bereavement in the death of his mother, Mrs. R. Ogden Doremus, wife of Prof. R. O. Doremus, and for many years a distinguished leader in the social and intellectual life of New York city.

Dr. EDWARD F. KERN, who has been associated during the last three years with Mr. Anson G. Betts in his well-known research work on electrolytic refining of lead, electrolytic treatment of slimes, etc., is now connected with the metallurgical department of the Columbia University. Dr. Kern is a graduate of the University of Pennsylvania and of Columbia University, having received the degree of Ph.D. from the latter university.

We are obliged to Mr. ALOIS VON ISAKOVICS, secretary of the New York Section of the American Electrochemical Society, for four most interesting photographs, taken at the recent general meeting of the Society in Boston. Two of them were



FROM LEFT TO RIGHT: J. W. RICHARDS, H. S. CARHART, W. H. WALKER, H. P. TALBOT, E. R. TAYLOR, S. S. SADTLER, G. DROBEGGE.

taken by flash-light after the banquet, and are excellent photographs, although, unfortunately, unsuitable for the making of half-tones. One of the other photographs is herewith reproduced, showing a group of distinguished members, with the two gentlemen in the center, to whom as chairman and secretary of the Boston committee, much of the great success of the meeting is to be credited, while the first two presidents of the Society are seen on the left.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

ELECTRIC SMELTING AND REDUCTION PROCESSES.

(Continued from page 208.)

590,673, September 28, 1897, Francis H. Soden, Chicago, Ill.

Supplements the ore-purification treatment of United States patents 290,213-4, and, in general, purifies ores of iron, gold, silver, copper, lead, etc. The ore, either before or after other treatment, is placed in an airtight receptacle having walls of firebrick or plumbago, through which pass horizontal resistance rods of platinum or carbon, arranged in two vertical series. The rods are connected to a dynamo, in multiple or in series, and the ore is thereby raised to a temperature of from 1200-1500° F. During the heating, superheated air or steam is first introduced, and the water, etc., in the ore is driven off. Superheated hydrogen is then passed into the vessel. The vessel is provided with a safety valve to relieve excess pressure.

591,355, October 5, 1897, Henri Moissan, Paris, France.

Produces titanium containing from 2 to 6 per cent of carbon by smelting a mixture of rutile 330 parts and carbon 96 parts, in a carbon crucible, with an arc of 1000 to 2000 amperes at 60 to 70 volts. The product, when reduced to a powder, is attacked by dilute hydrochloric acid, thus, distinguishing it from titanium carbide and titanium nitride. If the mixture be smelted with the current from a dynamo of 45 horse-power only, or with an arc of 400 amperes at 80 volts, the product is a reddish brown titanonitrogen compound, containing from 79 to 80 per cent of titanium and having a density of 5.02. To decarburize the titanium, it is broken into pieces and resmelted with titanic acid, by an arc of the specified intensity. If the quantity of carbon in the mixture is increased, titanium carbide, TiC, is produced, having the color of galena and the density of 4.3. The titanium when alloyed with iron or nickel is soluble in molten iron, cast iron or steel. Titanium steel may also be produced by electrically melting the iron in a crucible and adding briquettes of a mixture of rutile, carbon and a glutinous binder.

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